Korea Standard Testlab
107-27, Jangdeokdong-gil, Namyang-eup, Hwaseong-si, Gyeonggi-do, Korea
Tel : +82-31-356-7333 FAX : +82-31-356-7303

FCC TEST REPORT

Applicant Name	: Bhaptics, Inc.
Brand Name	: N/A
Applicant Address	: A606 Admin. B/D, 193 Munji-ro, Yuseong-gu, Daejeon, Korea
FCC ID	: 2AJ6BBHTTS5401
Products Name	: TACTOSY
Model No.	: BHTTS5401
Variant Model No.	: N/A
Products Manufacturer	: Bhaptics, Inc.
Test Standard	: FCC CFR 47 Part 15.247 Subpart C
Test Method	: KDB 558074 D01 v03r05 and ANSI C63.10:2013
Test Result	: PASS
Dates of Test	: October 14, 2016 to October 15, 2016
Date of Issue	: October 28, 2016
Test Laboratory	: Korea Standard Testlab FCC Registration No. : 251179

Tested by

Gyung-Nam Park
Test Engineer

Approved by

Yong-Seok You
Technical Manager

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1. General Information

1.1. Client Information

Applicant	:	Bhaptics, Inc.
Address of Applicant	:	A606 Admin. B/D, 193 Munji-ro, Yuseong-gu, Daejeon, Korea

1.2. General Description of E.U.T.

Product Name	:	TACTOSY
Model No.	:	BHTTS5401

1.3. Details of E.U.T.

Operating Frequency	:	2 402 MHz to 2 480 MHz
Type of Modulation	:	GFSK
Number of Channels	:	40 Channels
Channel Separation	:	2 MHz
Duty Cycle	:	Continuous operation possible for testing purposes
Antenna Type	:	Chip Antenna
Antenna gain	:	0.5 dBi
Speciality	:	Bluetooth specification version 4.2 (BLE)
Power Supply	:	Working voltage
Normal Test Voltage	:	DC 3.7 V

1.4. Test Facility

The test site and measurement facilities used to collect the radiated and conducted data are located at #107-27, Jangdeokdong-gil, Namyang-eup, Hwaseong-si, Gyeonggi-do, Korea. This test site has been accredited as a Conformity Assessment Body and the registration number for FCC test firm is 251179.

2. Test Equipment and Ancillaries used for Tests

No.	Test Equipment	Manufacturer	Model No.	Serial No.	Cal. Date	Next Cal. Date	Used equipment
1	Spectrum Analyzer	Agilent	E4440A	MY45304715	16.10.13	17.10.13	■
2	Frequency Counter	HP	5350B	3049A05530	16.06.02	17.06.02	□
3	DC Power Supply	ALINCO	DM-340MV	F001015	16.06.01	17.06.01	■
4	Signal Generator	Leader Electronics	3220	137231	16.06.01	17.06.01	□
5	Synthesized CW Generator	HP	83711B	US34490158	16.06.01	17.06.01	□
6	SYNTHESIZED SWEEPER	HP	8340B	2804A00830	16.06.01	17.06.01	■
7	Function Generator	IWATSU	SG-4105	62372780	16.06.01	17.06.01	□
8	Modulation Analyzer	Agilent	8901B	3438A05099	16.06.01	17.06.01	□
9	Audio Analyaer	Agilent	8903B	3279A18576	16.06.01	17.06.01	□
10	Power Meter	Agilent	E4418B	GB43312894	16.06.02	17.06.02	□
11	Power Sensor	HP	8485A	3316A14708	16.06.02	17.06.02	□
12	Power Sensor	Agilent	8482B	2703703543	16.06.02	17.06.02	□
13	Pre Amplifier	GTC	GA-1825A	GT0929/003	16.06.01	17.06.01	■
14	Attenuator	Weinsche	53-30-33	MG906	16.06.01	17.06.01	□
15	Step Attenuator	Agilent	8494B	MY41110204	16.06.01	17.06.01	□
16	Step Attenuator	Agilent	8495B	3308A17660	16.06.01	17.06.01	□
17	Step Attenuator	Agilent	8496B	US40152183	16.06.01	17.06.01	□
18	Attenuator	HP	30dB	N/A	16.06.01	17.06.01	□
19	Attenuator	TAE SUNG	SMA-1	N/A	16.06.01	17.06.01	□
20	Attenuator	TAE SUNG	SMA-2	N/A	16.06.01	17.06.01	□
21	Termination	KWANG YEOK	KYTE-NJ-150W	2040004	16.06.01	17.06.01	□
22	Spectrum Analyzer	LIG	ISA-265	L0812M002	16.10.18	17.10.18	□
23	Bluetooth Tester	TESCOM	TC-3000A	3000A590236	16.06.02	17.06.02	□

24	Loop ANT.	Com-Power	AL-130	121010	15.06.05	17.06.04	■
25	Horn ANT.	SCHWARZBECK	BBHA 9120D	831	16.07.21	18.07.21	■
26	Temp & Humidity Chamber	Seoksan Tech	SE-CT-02	S7400JD5340618	16.06.01	17.06.01	□
27	Test Receiver	LIG Nex1	LSA-265	L07098033	16.10.13	17.10.13	■
28	Test Receiver	ROHDE&SCHWARZ	ESPI	101014	16.06.01	17.06.01	■
29	Bi-log Antenna	SCHWARZBECK	VULB9160	3311	15.11.19	17.11.18	□
30	Bi-log Antenna	TDK RF Solutions Inc.	HLP-2006C	131010	16.09.23	18.09.23	■
31	AMPLIFIER	SONOMA	310N	251847	16.02.29	17.02.28	■
32	RMS Multimeter	The T&M ALLIANCE	FLUKE87	61160149	16.06.01	17.06.01	■
33	LISN	ROHDE & SCHWARZ	ENV216	101732	16.02.29	17.02.28	■
34	LISN	Kyoritsu	KNW-407	8-1010-14	16.06.02	17.06.02	■

3. Summary of Test Results

No	Test	Standard Sub-Class	Result
0	Antenna Requirement	§15.203,§15.247(c)	Compliant
1	Maximum Peak Output Power	§15.247(b)	Compliant
2	Peak Power Spectral Density	§15.247(e)	Compliant
3	Occupied 6dB Bandwidth	§15.247(a)	Compliant
4	Band Edges Compliance	§15.247(d)	Compliant
5	Conducted Spurious Emission	§15.247(d)	Compliant
6	Radiated Spurious Emission	§15.247, §15.205, §15.209	Compliant
7	AC Powerline Conducted Emission	§15.107, §15.207	Compliant
8	Radio Frequency Exposure Procedures	§2.1093	Compliant

4. Test Results

4.1. E.U.T. test conditions

Test Voltage: DC 3.7 V
Temperature: 23 °C ~ 25 °C
Humidity: 40 % R.H. ~ 50 % R.H.
Atmospheric Pressure: 100.0 kPa ~ 100.5 kPa
Test frequencies and frequency range:
- FCC Part 15 Section 15.31(m) :
Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:
- FCC Part 15 Section 15.33 (a) :
For an intentional radiator, the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in the following table:

Number of fundamental frequencies to be tested in EUT transmit band

Frequency range in which device operates	Number of frequencies	Location in frequency range of operation
1 MHz or less	1	Middle
1 MHz to 10 MHz	2	1 near top and 1 near bottom
More than 10 MHz	3	1 near top, 1 near middle and 1 near bottom

Frequency range of radiated emission measurements

Lowest frequency generated in the device	Upper frequency range of measurement
9 kHz to below 10 GHz	10th harmonic of highest fundamental frequency or to 40 GHz, whichever is lower
At or above 10 GHz to below 30 GHz	5th harmonic of highest fundamental frequency or to 100 GHz, whichever is lower
At or above 30 GHz	5th harmonic of highest fundamental frequency or to 200 GHz, whichever is lower, unless otherwise specified

4.1.1. EUT channels and frequencies list

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2 402	20	2 442
1	2 404	21	2 444
2	2 406	22	2 446
3	2 408	23	2 448
4	2 410	24	2 450
5	2 412	25	2 452
6	2 414	26	2 454
7	2 416	27	2 456
8	2 418	28	2 458
9	2 420	29	2 460
10	2 422	30	2 462
11	2 424	31	2 464
12	2 426	32	2 466
13	2 428	33	2 468
14	2 430	34	2 470
15	2 432	35	2 472
16	2 434	36	2 474
17	2 436	37	2 476
18	2 438	38	2 478
19	2 440	39	2 480

4.1.2. Test Mode

All test mode(s) and condition(s) mentioned were considered and evaluated respectively by performing full tests, the worst data were recorded and reported.

Test mode	Low channel	Middle channel	High channel
Transmitting	2 402 MHz	2 440 MHz	2 480 MHz

4.2. Antenna

4.2.1. Requirement

- FCC Part 15 C section 15.203 :

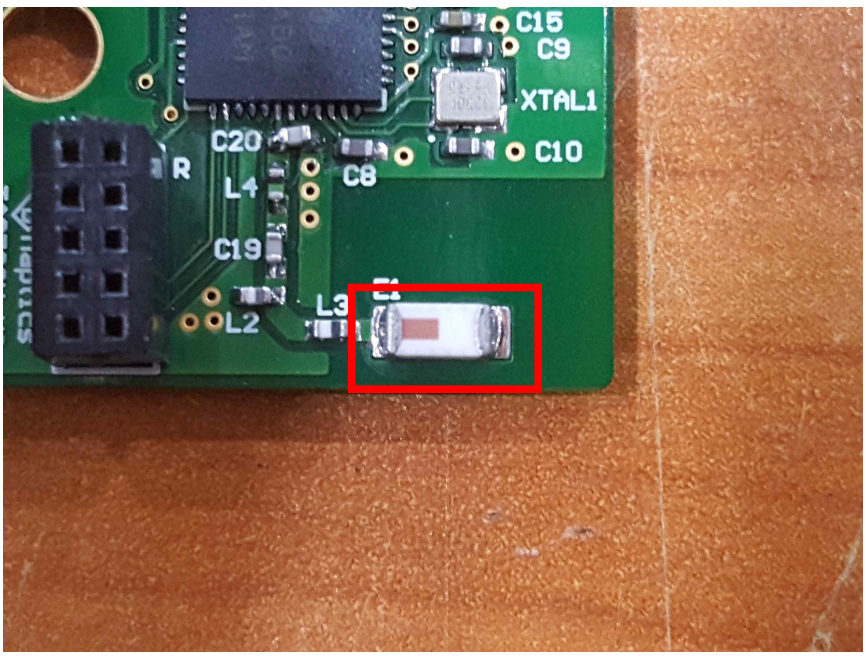
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

- FCC Part 15 C section 15.247(c) (1)(ⅰ) :

Systems operating in the 2 400 ~ 2 483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

4.2.2. Test Result

The antenna is Chip antenna. The directional gain of the antenna is 0.5 dBi. Please refer to the internal photographs of EUT.



Test result : The unit does meet the FCC requirements.

4.3. Occupied 6 dB Bandwidth

4.3.1. Requirement

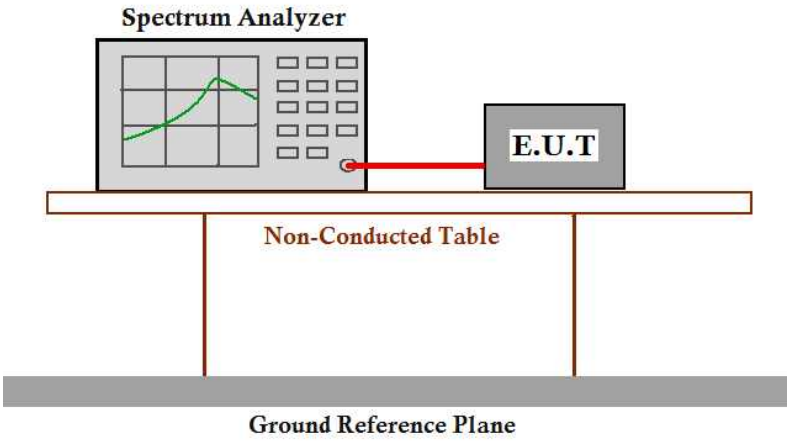
- FCC Part 15 C section 15.247(a)(2) :

Systems using digital modulation techniques may operate in the 902 ~ 928 MHz, 2 400 ~ 2 483.5 MHz, and 5 725 ~ 5 850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

4.3.2. Test method

KDB 558074 D01 v03r05 and ANSI C63.10

4.3.3. Test Configuration



4.3.4. Test Procedure

1) Remove the antenna from the EUT and then connect a low attenuation RF cable from the antenna port to the spectrum.
2) Set the spectrum analyzer :
   a) Set RBW = 100 kHz.
   b) Set the video bandwidth (VBW) ≥ 3 × RBW.
   c) Detector = Peak.
   d) Trace mode = max hold.
   e) Sweep = auto couple.
   f) Allow the trace to stabilize.
   g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

4.3.5. Test result

Test mode : BLE mode

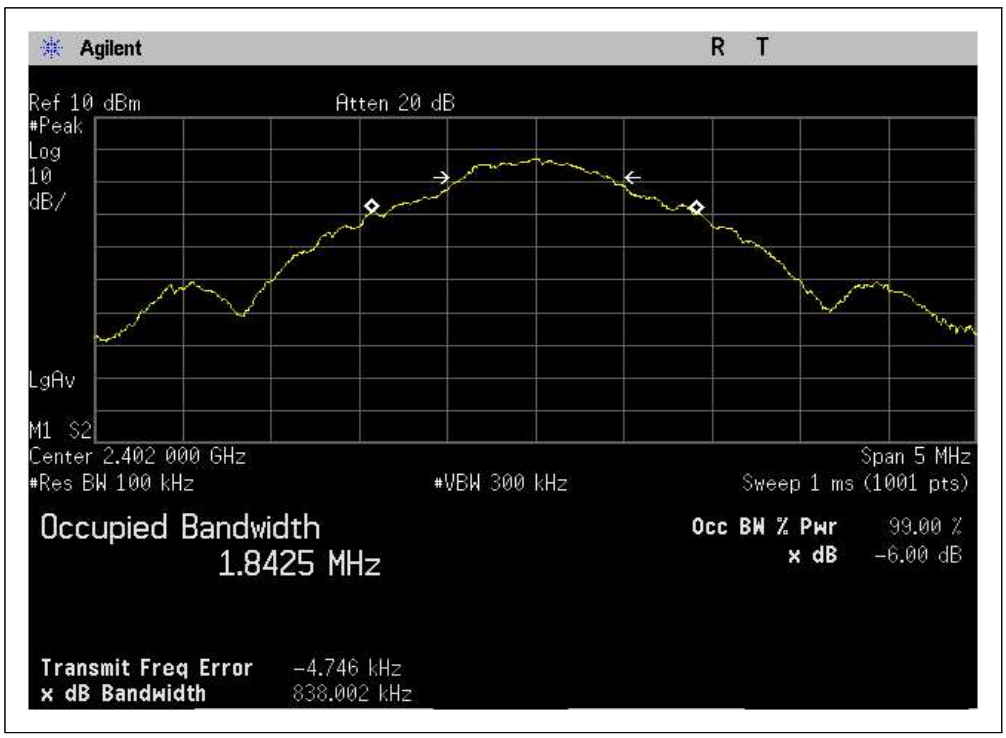
Test Channel	Frequency (MHz)	6 dB Bandwidth (kHz)	Limit (kHz)	Result
Low	2 402	838.00	≥500	Pass
Middle	2 440	817.47	≥500	Pass
High	2 480	819.86	≥500	Pass

Test Channel	Frequency (MHz)	99% Bandwidth (kHz)	Limit (kHz)	Result
Low	2 402	1842.50	N/A	N/A
Middle	2 440	1863.80	N/A	N/A
High	2 480	1919.20	N/A	N/A

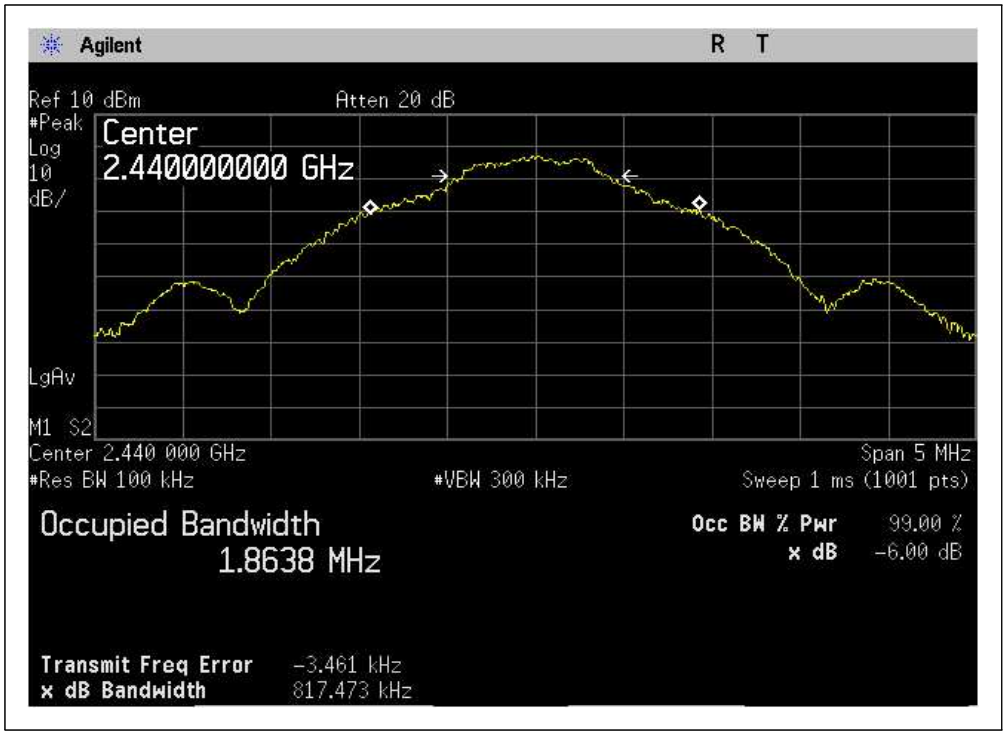
Test result : The unit does meet the FCC requirements.

Please refer to the following test plots:

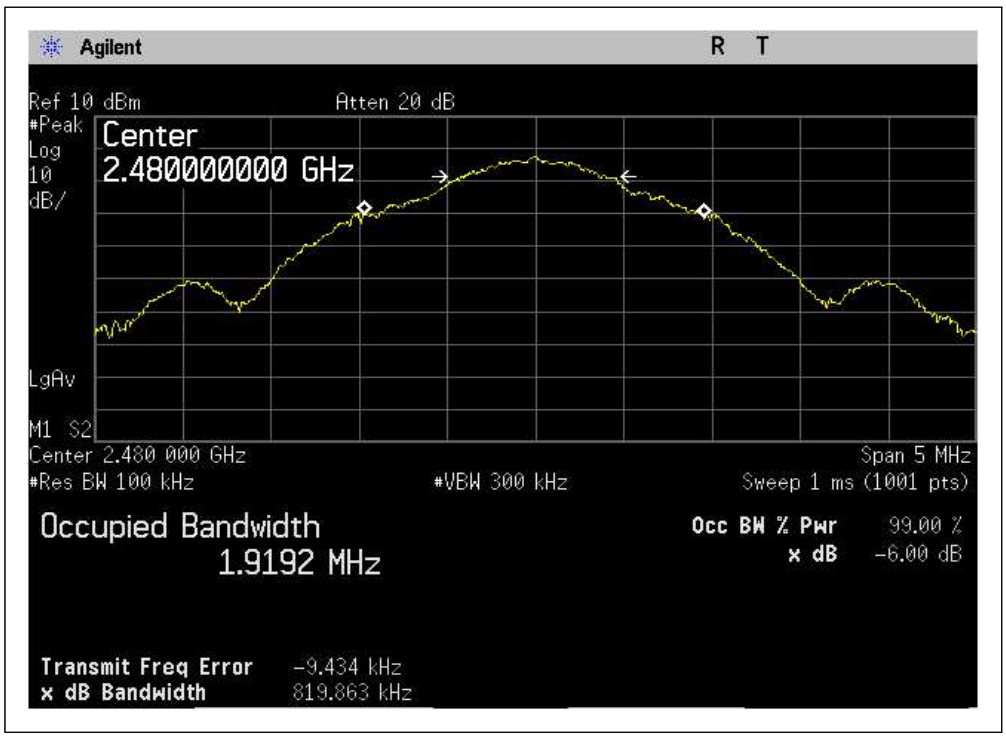
Low Channel(2 402 MHz):



Middle Channel(2 440 MHz):



High Channel(2 480 MHz):



4.4. Maximum Peak Output Power

4.4.1. Requirement

- FCC Part 15 C section 15.247 (b)(3):

For systems using digital modulation in the 902 ~ 928 MHz, 2 400 ~ 2 483.5 MHz, and 5 725 ~ 5 850 MHz bands: 1 Watt.

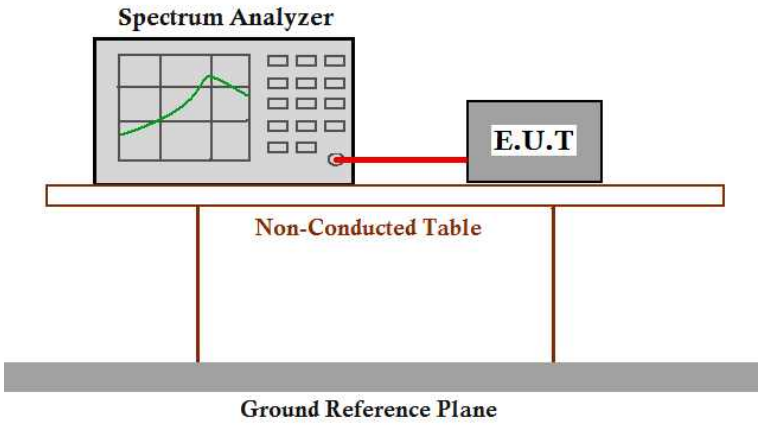
- FCC Part 15 C section 15.247 (b)(4):

Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraph (b) (1), (b) (2), and (b) (3) of section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

4.4.2. Test Method

KDB 558074 D01 v03r05 and ANSI C63.10

4.4.3. Test Configuration



4.4.4. Test Procedure

1) Remove the antenna from the EUT and then connect a low attenuation RF cable from the antenna port to the spectrum.
2) Set the spectrum analyzer:
   a) Set RBW ≥ DTS bandwidth
   b) Set the video bandwidth (VBW) ≥ 3 × RBW.
   c) Set span ≥ 3 × RBW.
   d) Sweep time = auto couple.
   e) Detector = Peak.
   f) Trace mode = max hold.
   g) Allow the trace to stabilize.
   h) Use peak marker function to determine the peak amplitude level.

4.4.5. Test result

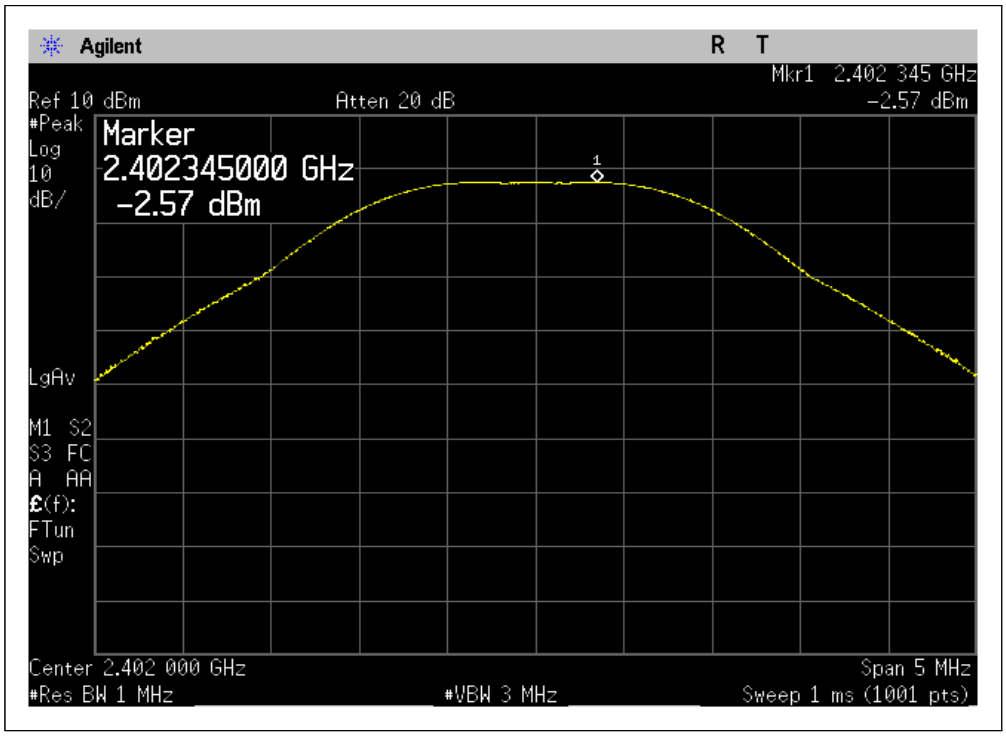
Test mode : BLE mode

Test Channel	Frequency (MHz)	Measured Channel Power (dBm)	Measured Channel Power (mW)	Limit (mW)	Result
Low	2 402	-2.57	0.55	1000.00	Pass
Middle	2 440	-2.26	0.59	1000.00	Pass
High	2 480	-2.42	0.57	1000.00	Pass

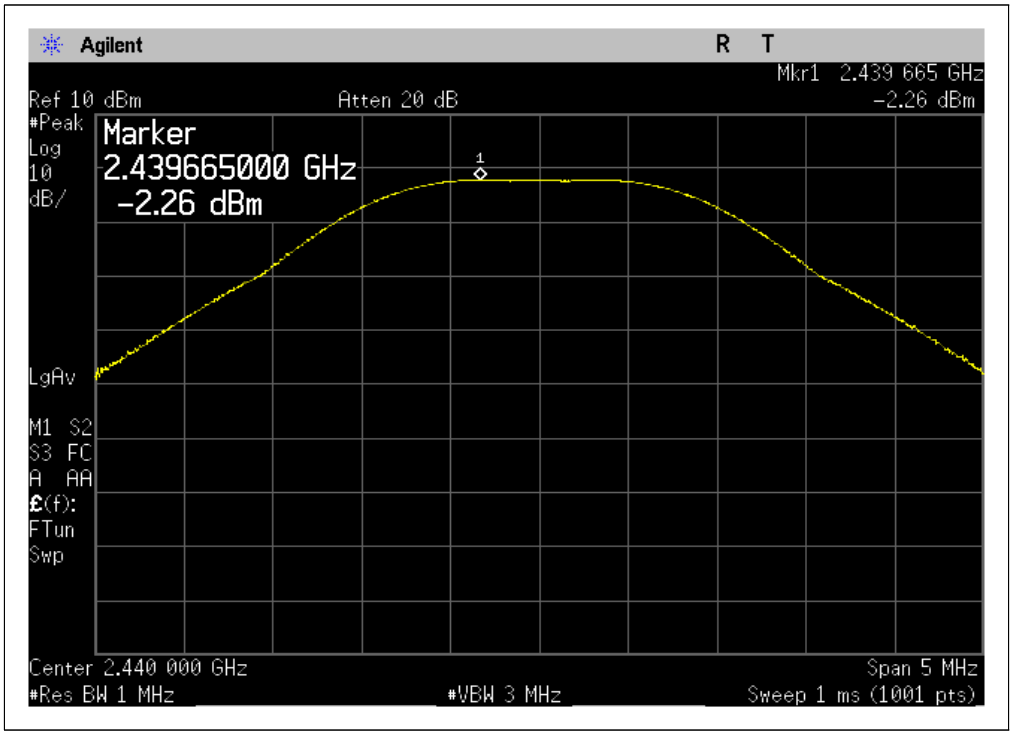
This unit does meet the FCC requirements.

Please refer to the following test plots:

Low Channel(2 402 MHz):



Middle Channel(2 440 MHz):



High Channel(2 480 MHz):

4.5. Peak Power Spectral Density

4.5.1. Requirement

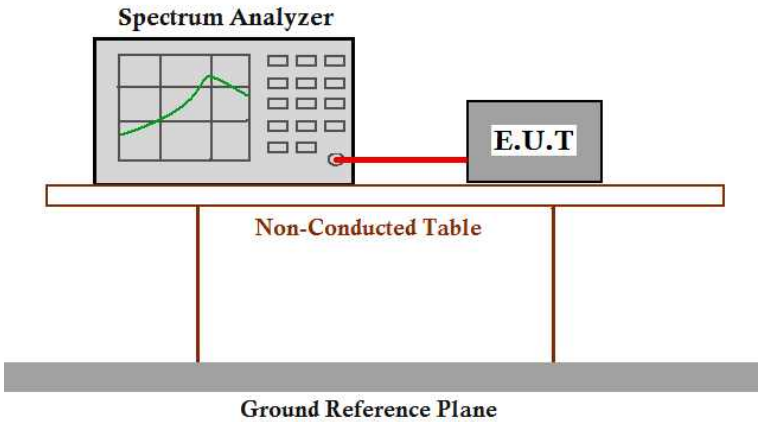
- FCC Part 15 C section 15.247 (e):

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

4.5.2. Test Method

KDB 558074 D01 v03r05 and ANSI C63.10

4.5.3. Test Configuration



4.5.4. Test Procedure

1) Remove the antenna from the EUT and then connect a low attenuation RF cable from the antenna port to the spectrum.
2) Set the spectrum analyzer:
   a) Set analyzer center frequency to DTS channel center frequency.
   b) Set the span to 1.5 times the DTS bandwidth.
   c) Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
   d) Set the VBW ≥ 3 × RBW.
   e) Detector = peak.
   f) Sweep time = auto couple.
   g) Trace mode = max hold.
   h) Allow trace to fully stabilize.
   i) Use the peak marker function to determine the maximum amplitude level within the RBW.
   j) If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

4.5.5. Test result

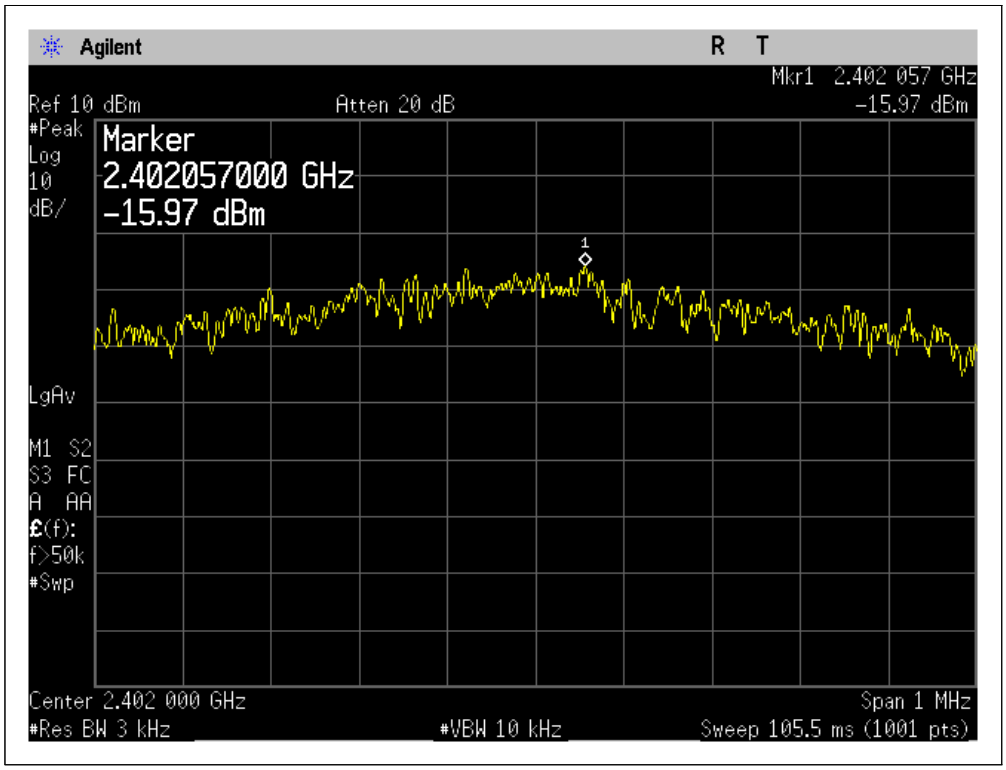
BLE mode:

Test Channel	Frequency (MHz)	Measured Peak Power Spectral Density (dBm/3 kHz)	Limit (dBm/3 kHz)	Result
Low	2 402	-15.97	8	Pass
Middle	2 440	-14.95	8	Pass
High	2 480	-16.64	8	Pass

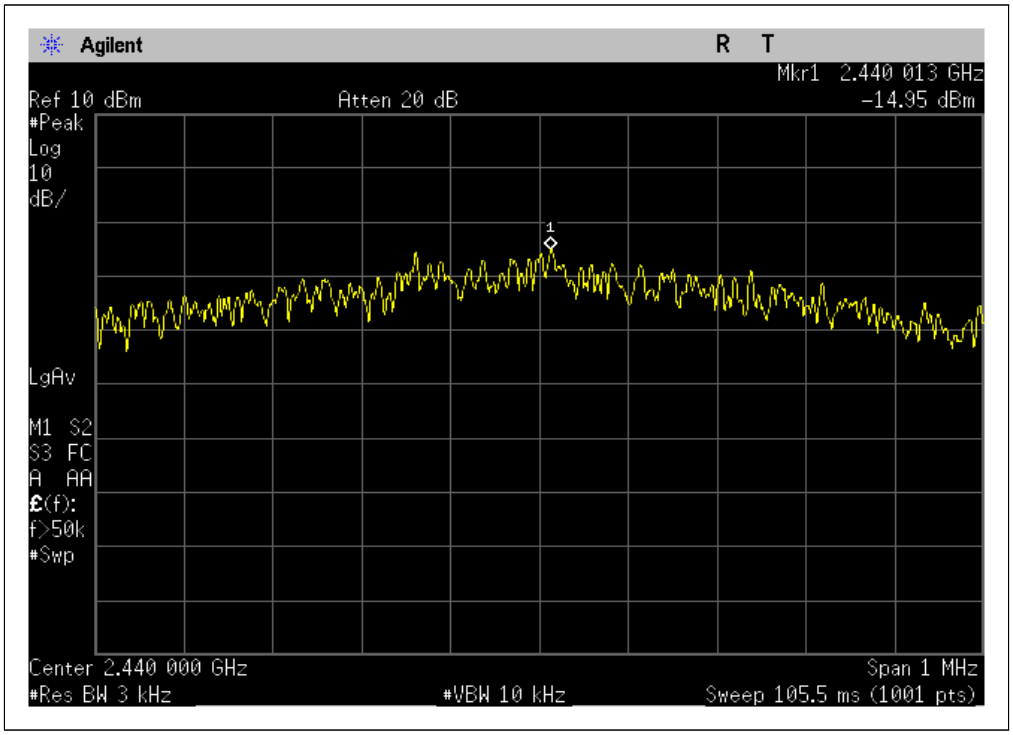
This unit does meet the FCC requirements.

Please refer to the following test plots:

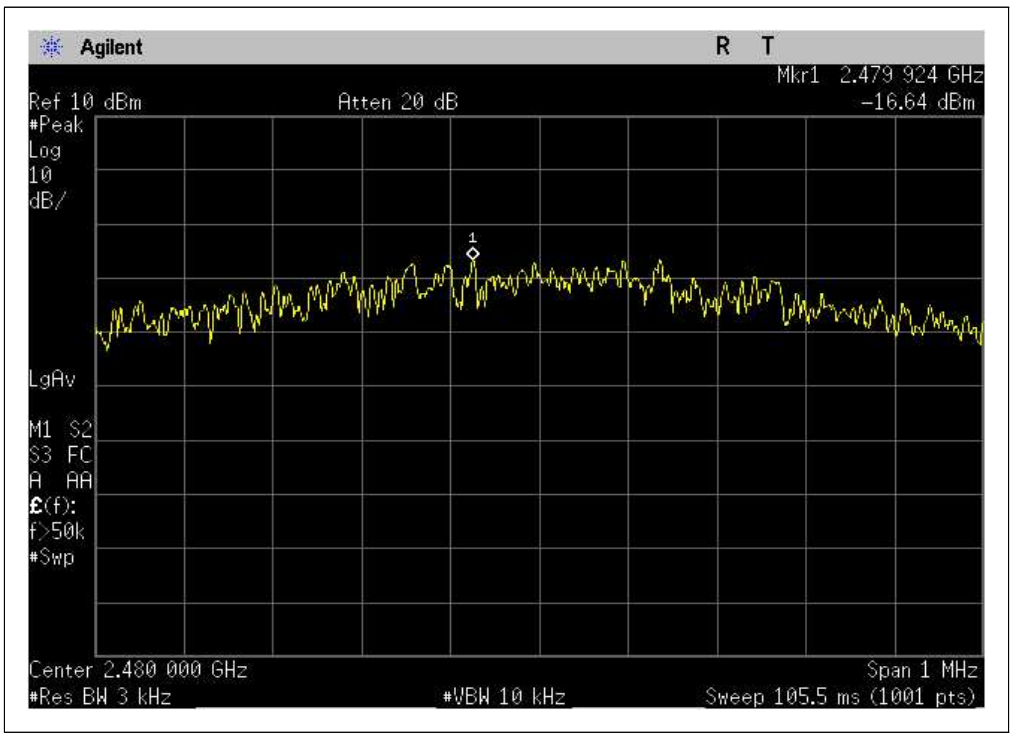
Low Channel(2 402 GHz):



Middle Channel(2 440 GHz):



High Channel(2 480 GHz):



4.6. Conducted Spurious Emissions

4.6.1. Requirement

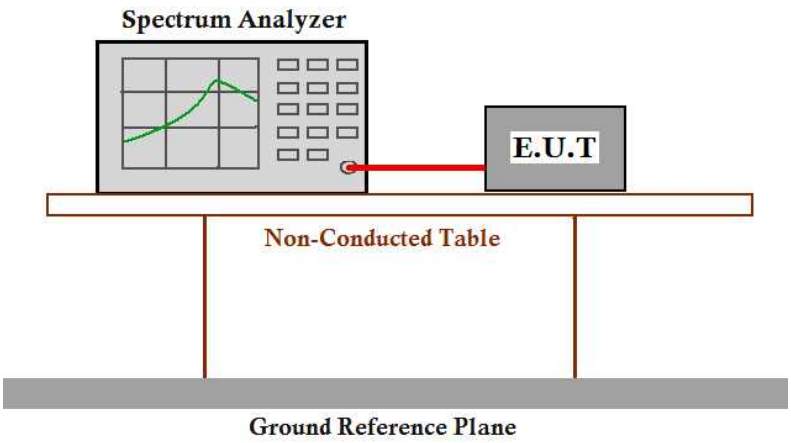
- FCC Part15 C section 15.247 (d) :

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating. The radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. Based on either an RF conducted or a radiated measurement. Provided the transmitter demonstrates compliance with the peak conducted power limits.

4.6.2. Test Method

KDB 558074 D01 v03r05 and ANSI C63.10

4.6.3. Test Configuration



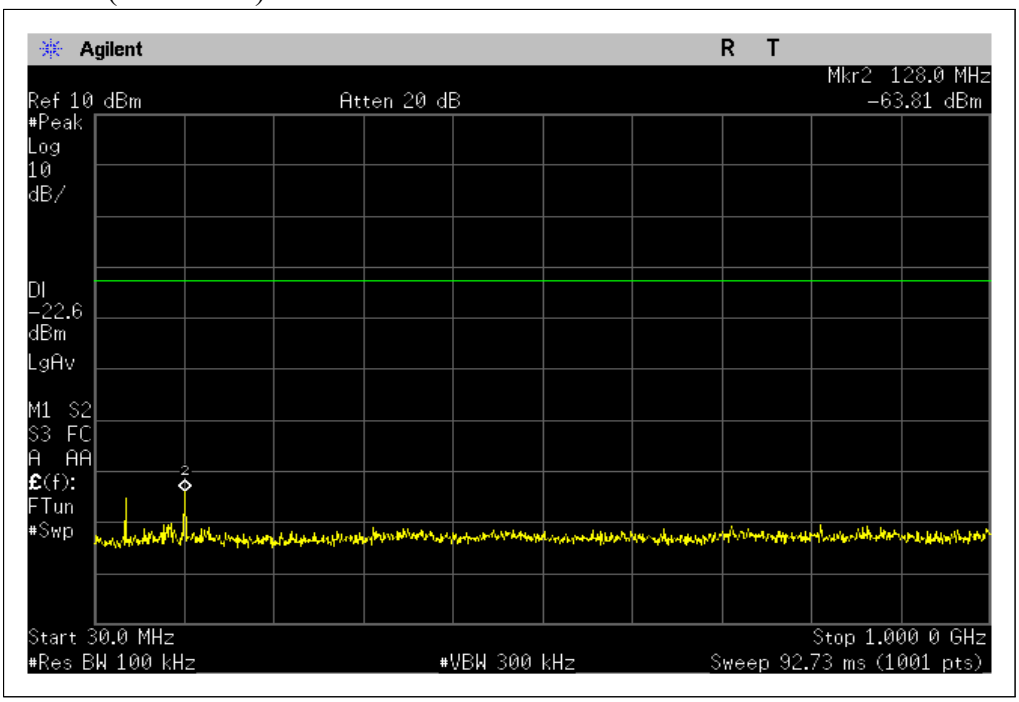
4.6.4. Test Procedure

1) Remove the antenna from the EUT and then connect a low attenuation RF cable from the antenna port to the spectrum.
2) Set the spectrum analyzer:
   a) Set the RBW = 100 kHz.
   b) Set the VBW = 300 kHz.
   c) Detector = peak.
   d) Sweep time = auto couple.
   e) Trace mode = max hold.
   f) Scan up through 10th harmonic.

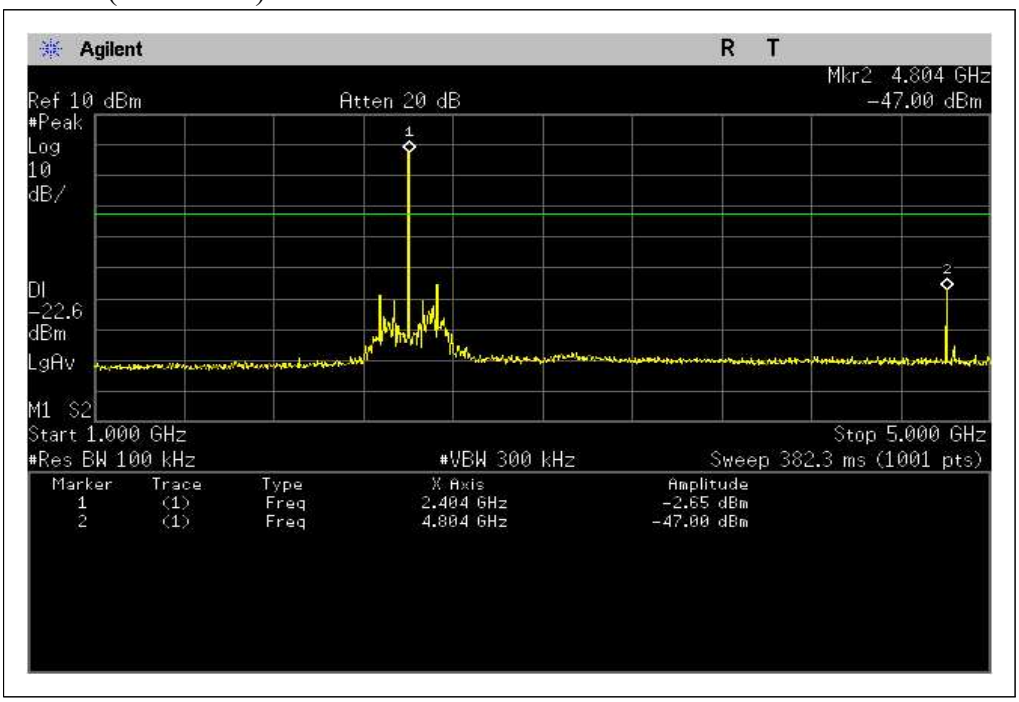
4.6.5. Test result

Test mode : 802.11b

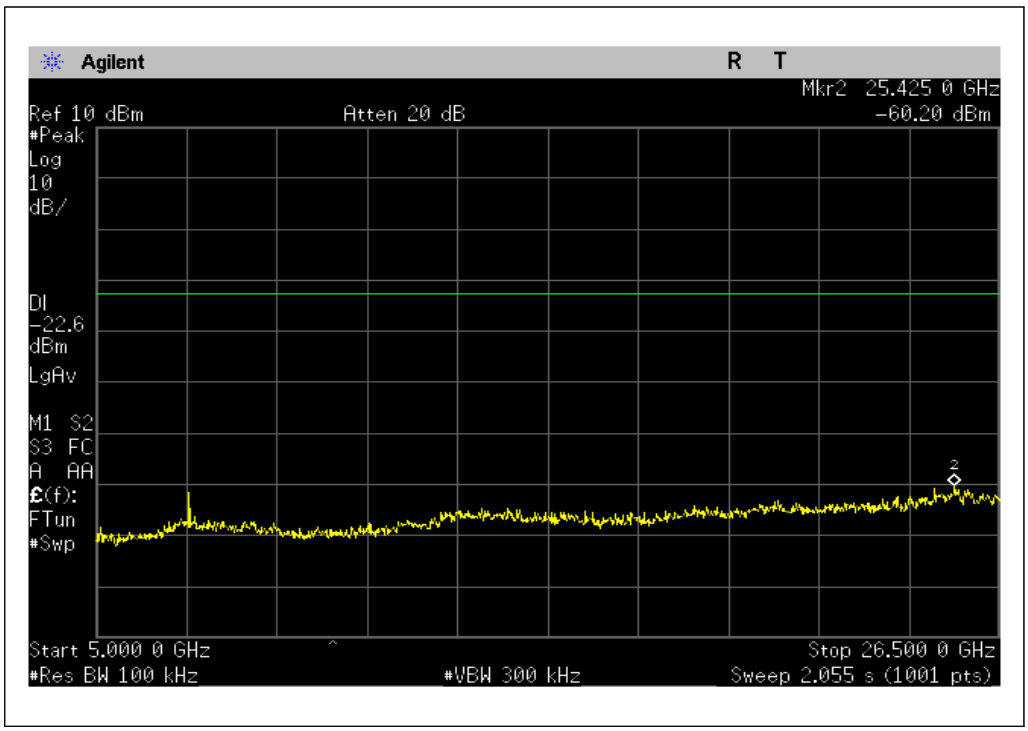
Low Channel(2 402 MHz) : 30 MHz to 1 GHz



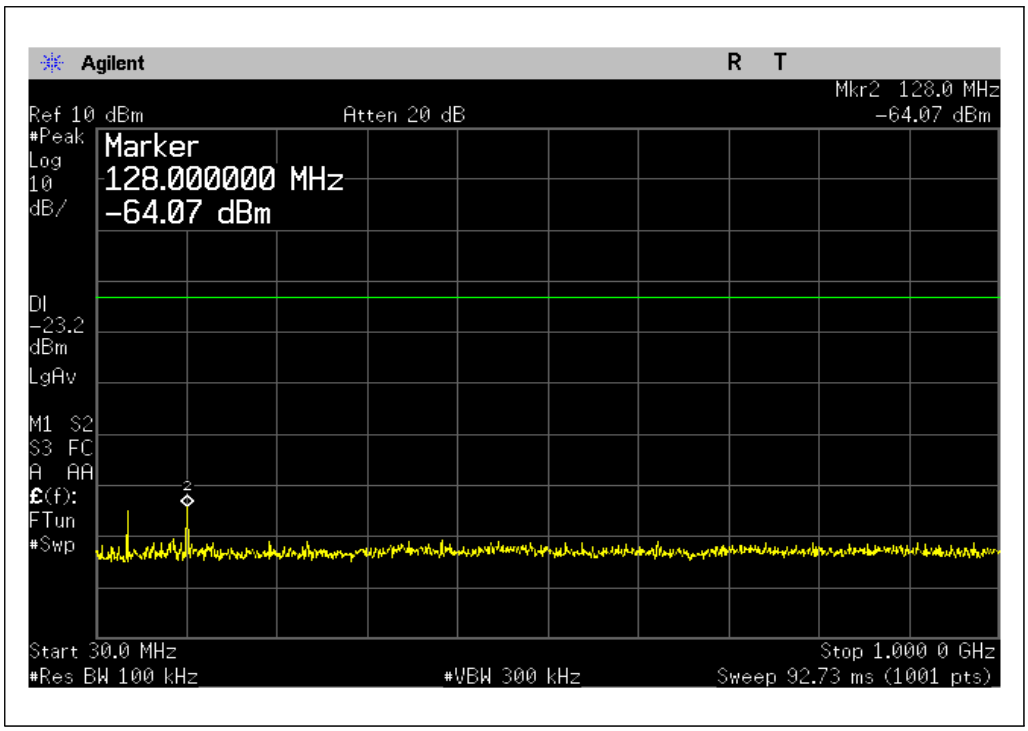
Low Channel(2 402 MHz) : 1 GHz to 5 GHz



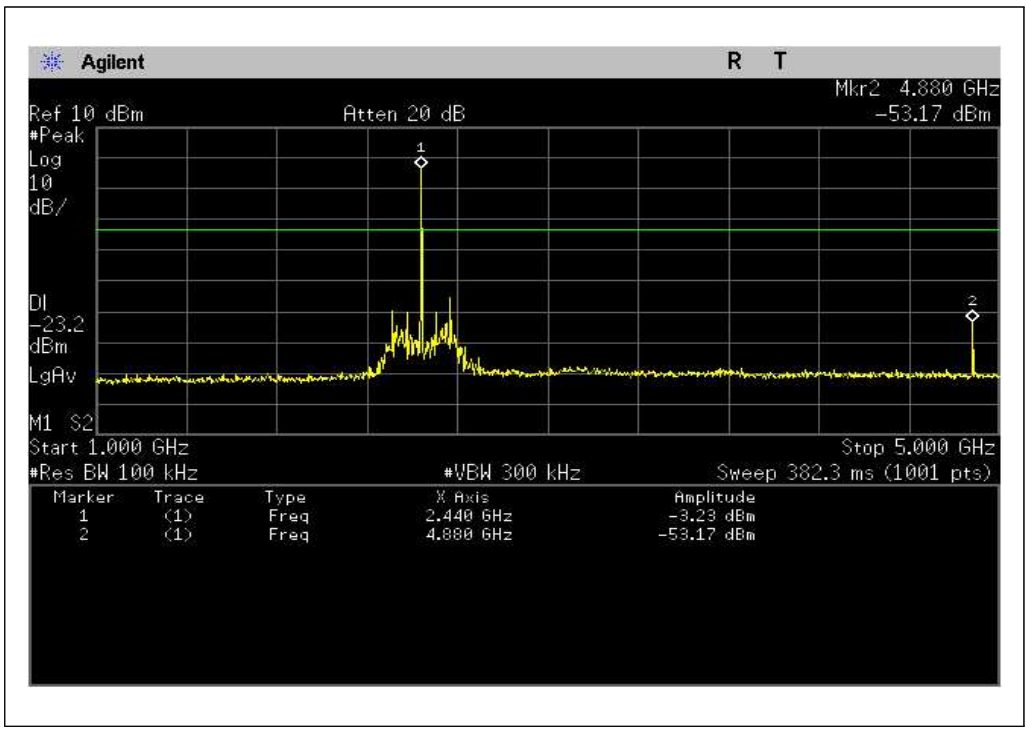
Low Channel(2 402 MHz) : 5 GHz to 26.5 GHz



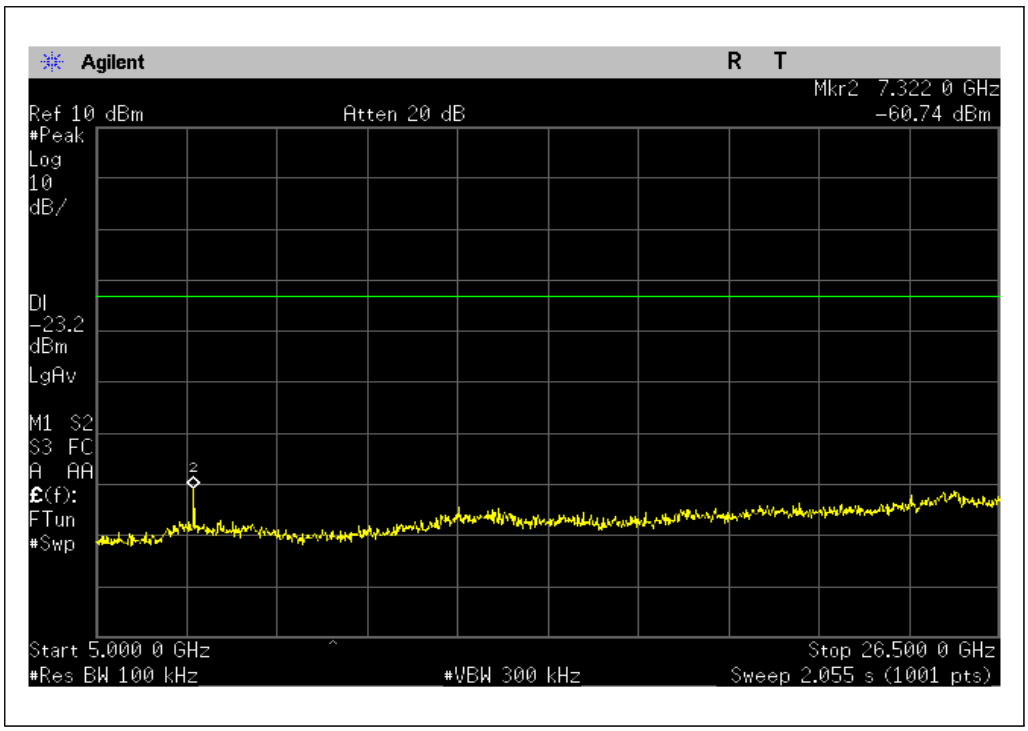
Middle Channel(2 440 MHz) : 30 MHz to 1 GHz



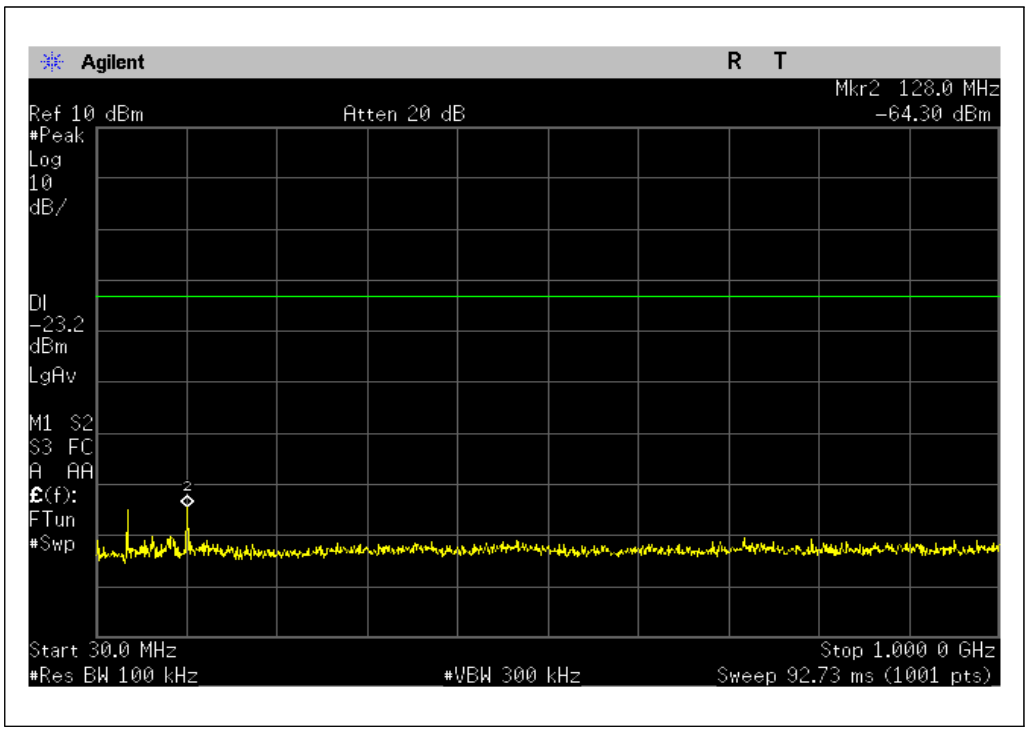
Middle Channel(2 440 MHz) : 1 GHz to 5 GHz



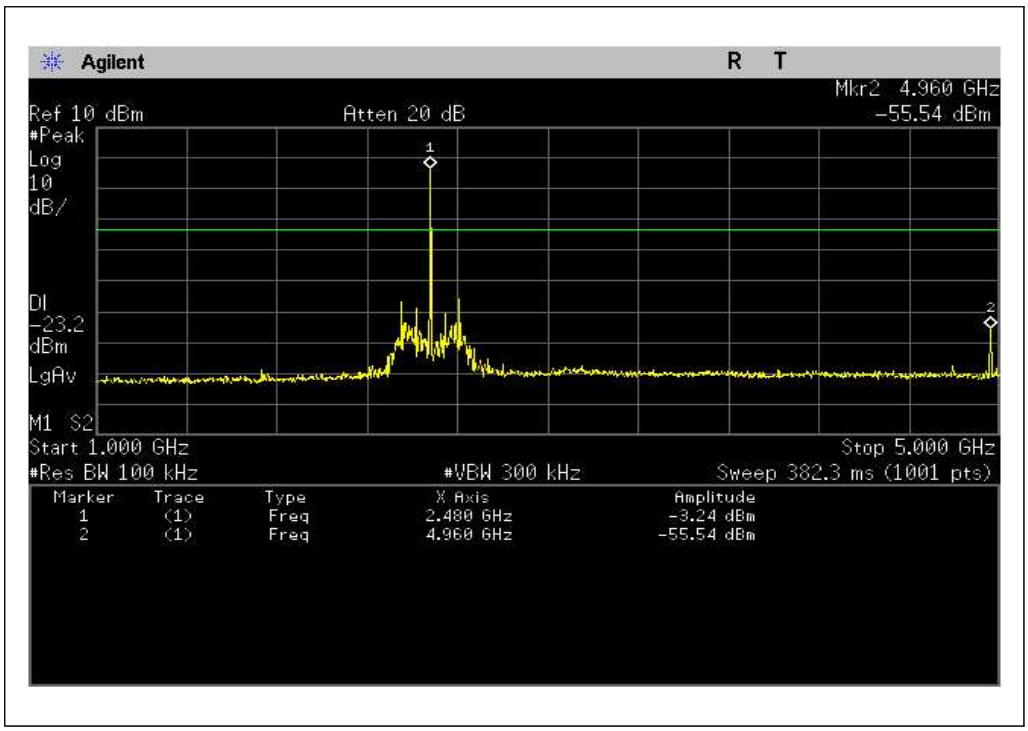
Middle Channel(2 440 MHz) : 5 GHz to 26.5 GHz



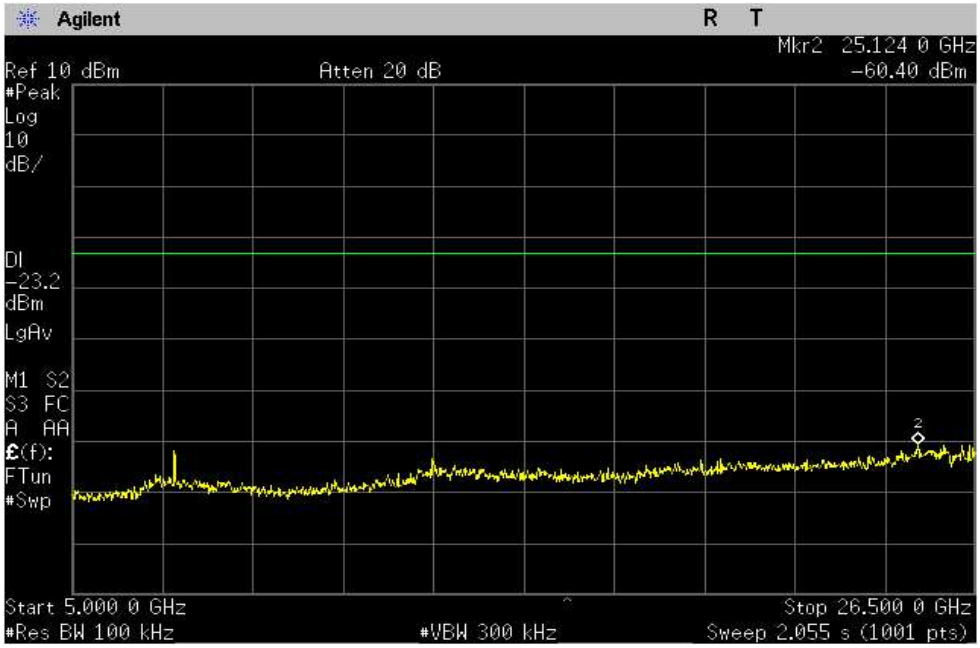
High Channel(2 480 MHz) : 30 MHz to 1 GHz



High Channel(2 480 MHz) : 1 GHz to 5 GHz



High Channel(2 480 MHz) : 5 GHz to 26.5 GHz



4.7. Radiated Spurious Emission

4.7.1. Requirement

- FCC Part15 C section 15.247 (d) :

In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limited specified in Section 15.209(a) (see Section 15.205(c)).

4.7.2. Test Method

ANSI C63.10

1) Test site

Measurement Distance : 3 m

2) Receiver setup

Frequency	Detector	RBW	VBW	Remark
9 kHz ~ 150 kHz	Quasi-peak	200 Hz	1 kHz	Quasi-peak Value
150 kHz ~ 30 MHz	Quasi-peak	9 kHz	30 kHz	Quasi-peak Value
30 MHz ~ 1 GHz	Quasi-peak	120 kHz	300 kHz	Quasi-peak Value
Above 1 GHz	Peak	1 MHz	3 MHz	Peak Value
	RMS	1 MHz	3 MHz	Average Vaile

3) Limit

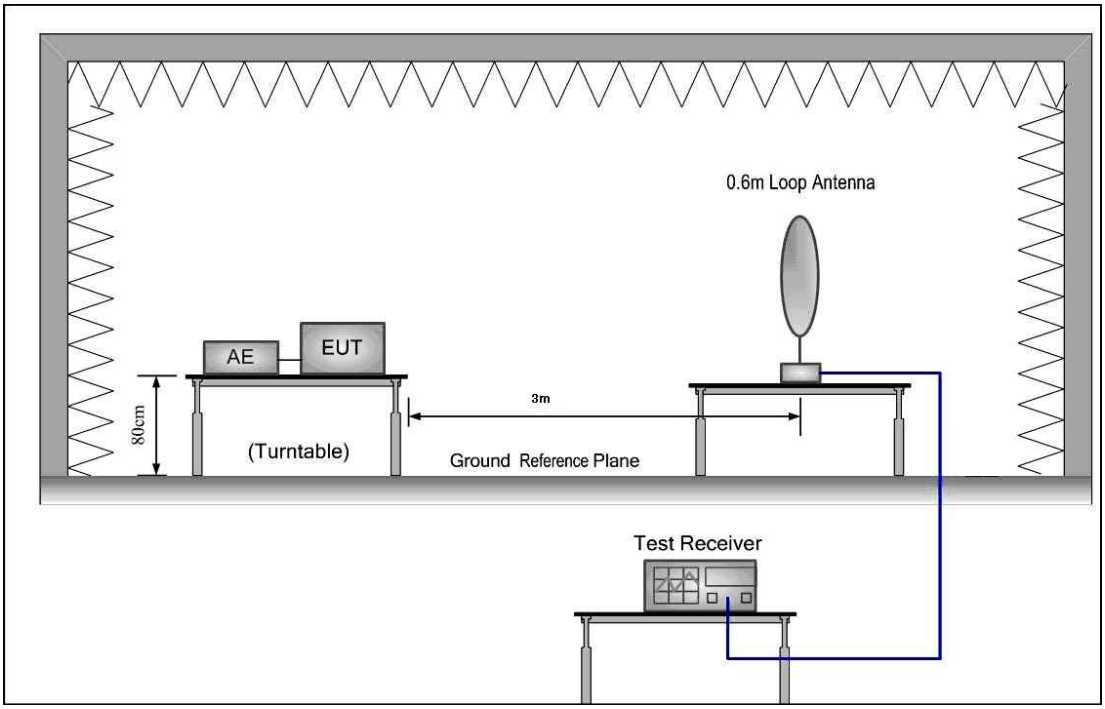
Frequency	Field Strength (microvolts/meter)	Distance (meter)	Remark
9 kHz ~ 490 kHz	2400/F(kHz)	300	Quasi-peak Vaule
490 kHz ~ 1.705 MHz	24000/F(kHz)	30	Quasi-peak Vaule
1.705 MHz ~ 30 MHz	30	30	Quasi-peak Vaule
30 MHz ~ 88 MHz	100	3	Quasi-peak Vaule
88 MHz ~ 216 MHz	150	3	Quasi-peak Vaule
216 MHz ~ 960 MHz	200	3	Quasi-peak Vaule
960 MHz ~ 1 GHz	500	3	Quasi-peak Vaule
Above 1 GHz	500	3	Average Value
	5000	3	Peak Value

4) Test Frequency Range

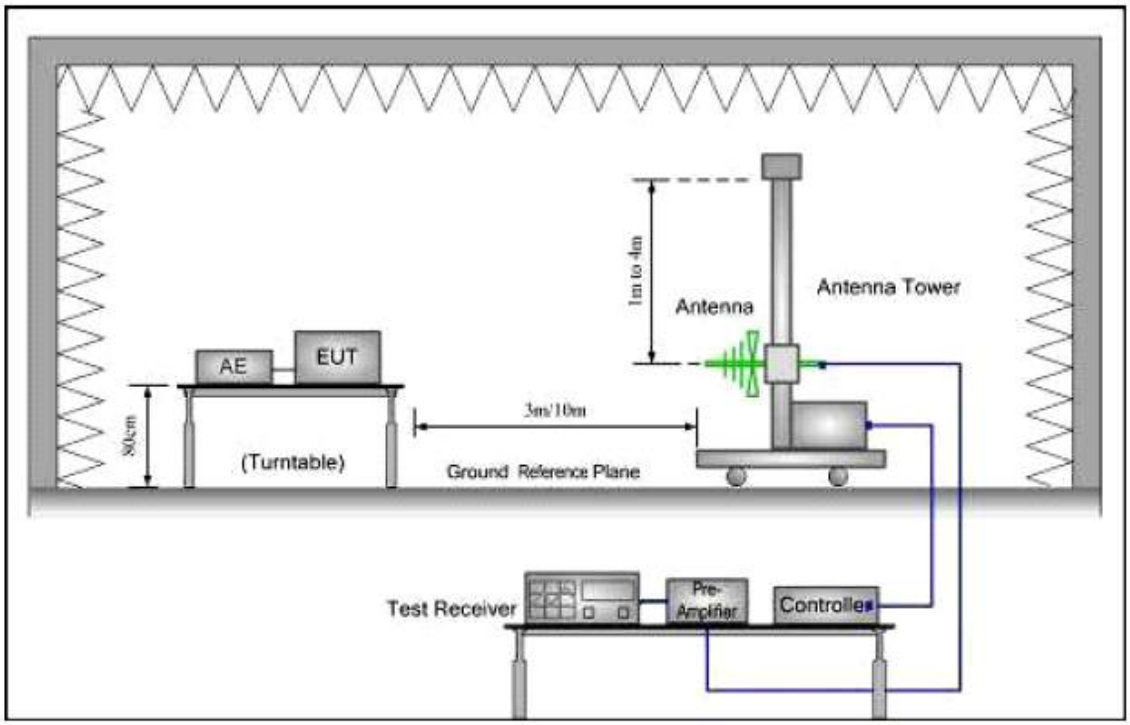
9 kHz ~ 26.5 GHz

4.7.3. Test Configuration

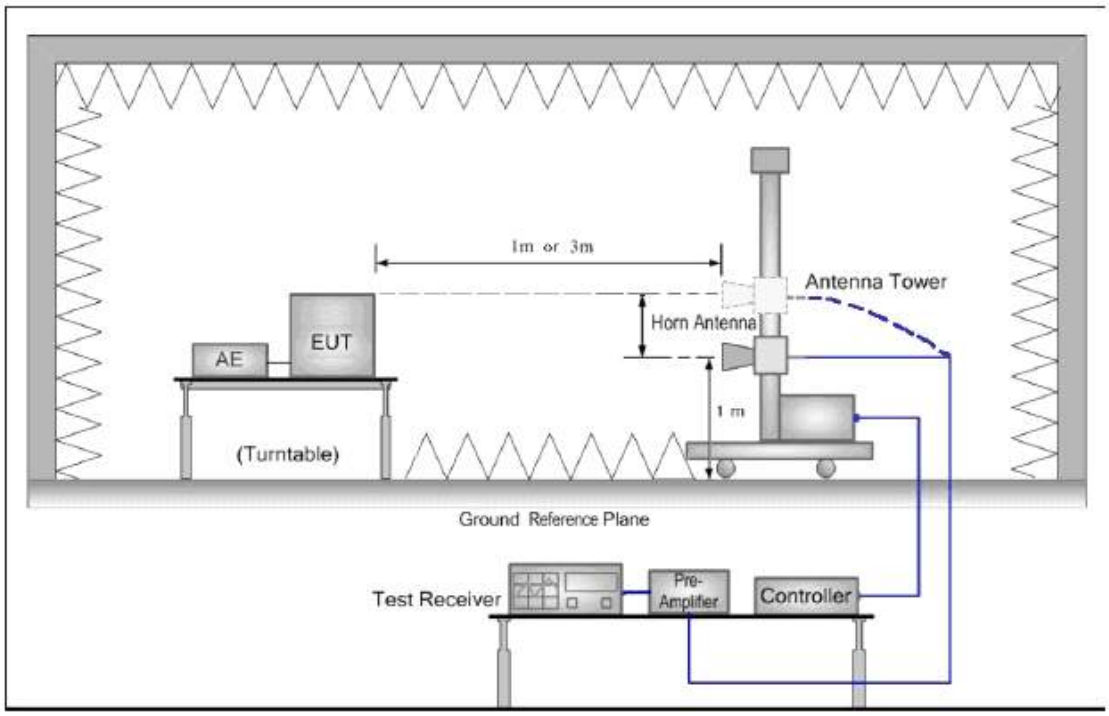
1) 9 kHz to 30 MHz emissions:



2) 30 MHz to 1 GHz emissions:



3) 1 GHz to 26.5 GHz emissions:



4.7.4. Test Procedure

1) The EUT was placed on the top of a turntable, which was 0.8 m above the ground for below 1 GHz and 1.5 m for above 1 GHz.
2) The turntable was rotated 360 degrees to determine the position of the highest radiation.
3) The EUT was set 3 m away from interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
4) The antenna height is varied from on meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarization of antenna are set to make the measurement.
5) For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1m to 4m and the turntable was turned from 0 degrees to 360 degrees to find the maximum reading.
6) The test-receiver system was set to Peak Detection Function and Specified Bandwidth with Maximum Hold Mode.

4.7.5. Test result

- All Radiated Spurious Emission tests were performed in X, Y, Z axis direction. And only the worst axis test condition was recorded in this test report.

1) Test at low Channel (2 402 MHz) in transmitting status

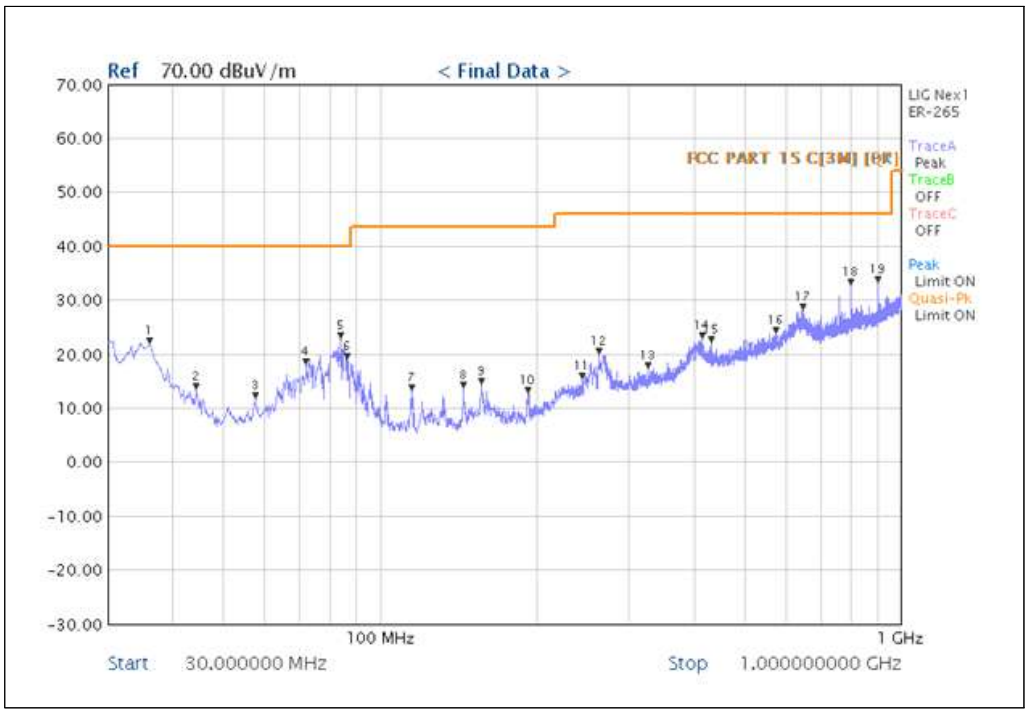
a) Field Strength of unwanted emissions for frequency range 9 kHz ~ 30 MHz.

(Detect mode : Quasi-Peak)

The measurements with active loop antenna were greater than 20 dB below the limit, so the test data were not recorded in the test report.

b) Spurious emissions for frequency range 30 MHz ~ 1 GHz. (Detect mode : Quasi-Peak)

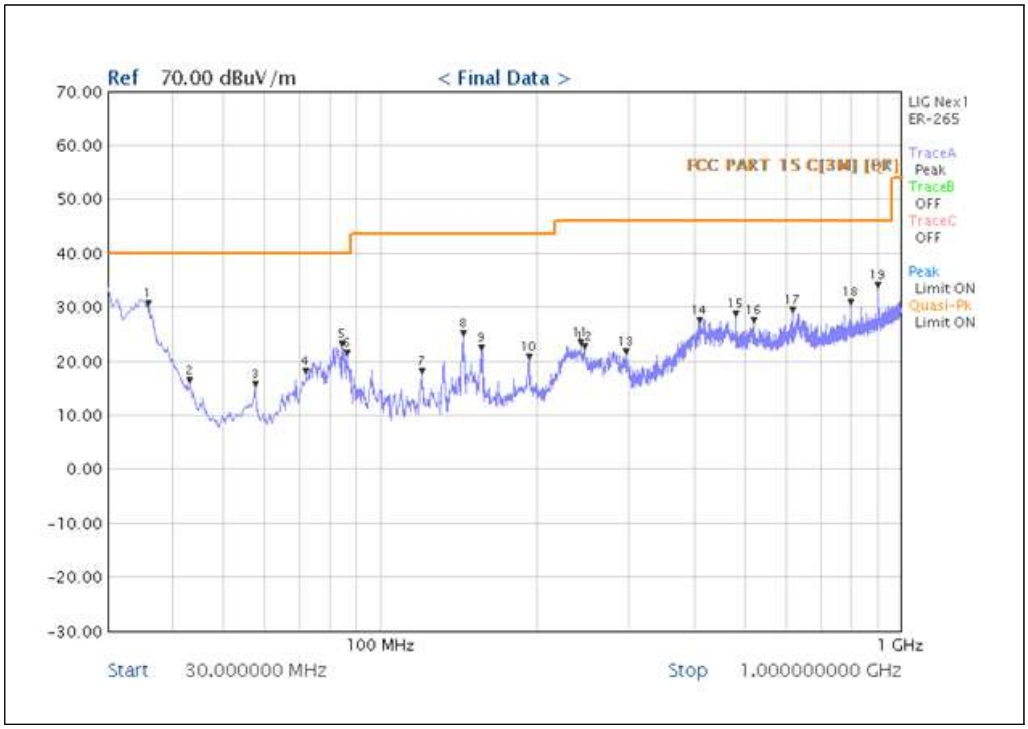
Vertical: Level (dBμV/m)



Frequency (MHz)	Detect Mode	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
143.98	Quasi-Peak	V	18.70	43.50	24.80
409.30	Quasi-Peak	V	28.84	46.00	17.16

* Remark:
1) The Emission Level values are included “Correction Factor”
2) Correction Factor = “Antenna Factor” + “Cable Loss” - “Amp. Gain”

Horizontal: Level (dBμV/m)



Frequency (MHz)	Detect Mode	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
143.98	Quasi-Peak	H	20.46	43.50	23.04
409.26	Quasi-Peak	H	28.87	46.00	17.13

* Remark:
1) The Emission Level values are included “Correction Factor”
2) Correction Factor = “Antenna Factor” + “Cable Loss” - “Amp. Gain”.

c) Harmonics & Spurious emissions for frequency range 1 GHz ~ 26.5 GHz. [Peak & average measurement]

Peak Measurement :

Frequency (MHz)	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2663.71	V	50.16	74.00	23.84
2689.37	H	48.15	74.00	25.85
4492.96	H	49.68	74.00	24.32
5821.69	V	50.11	74.00	23.89

Average Measurement :

Frequency (MHz)	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2678.63	H	42.82	54.00	11.18
2681.23	V	42.64	54.00	11.36
5770.19	V	42.88	54.00	11.12
5813.24	H	40.13	54.00	13.87

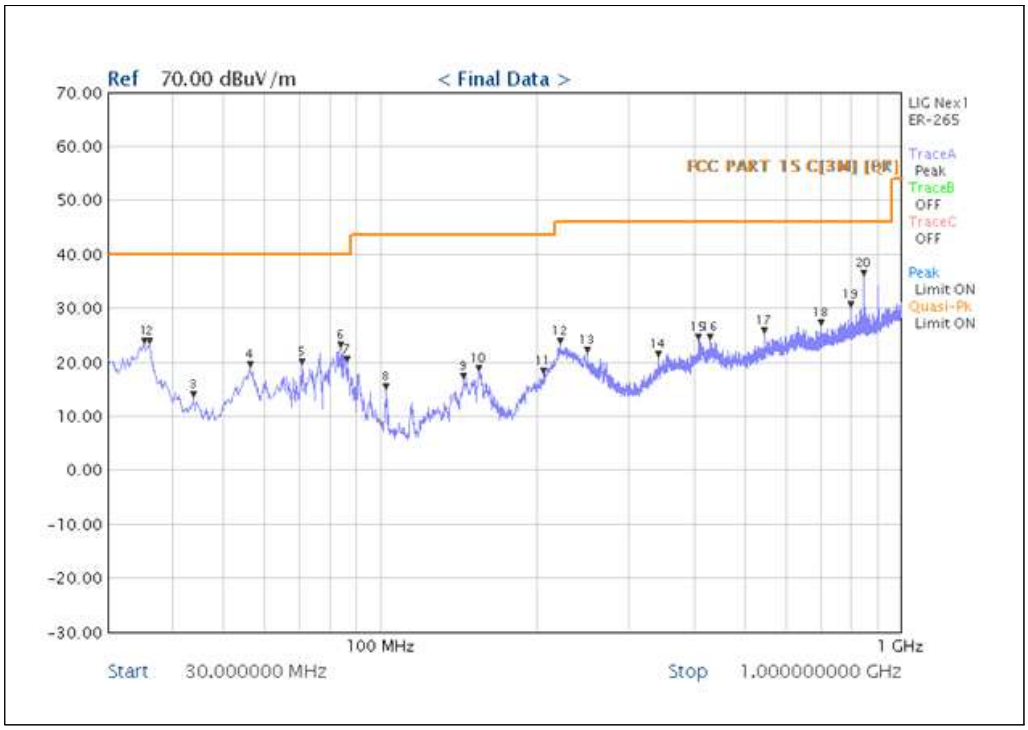
* Remark:
1) The Emission Level values are included “Correction Factor”
2) Correction Factor = “Antenna Factor” + “Cable Loss” - “Amp. Gain”
3) As shown in Section, for frequencies above 1 GHz. the above field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.
4) The test only perform the EUT in transmitting status since the test frequencies were over 1 GHz only required transmitting status.

2) Test at middle Channel (2 440 MHz)in transmitting status

a) Field Strength of unwanted emissions for frequency range 9 kHz ~ 30 MHz.
(Detect mode : Quasi-Peak)
The measurements with active loop antenna were greater than 20 dB below the limit, so the test data were not recorded in the test report.

b) Spurious emissions for frequency range 30 MHz ~ 1 GHz. (Detect mode : Quasi-Peak)

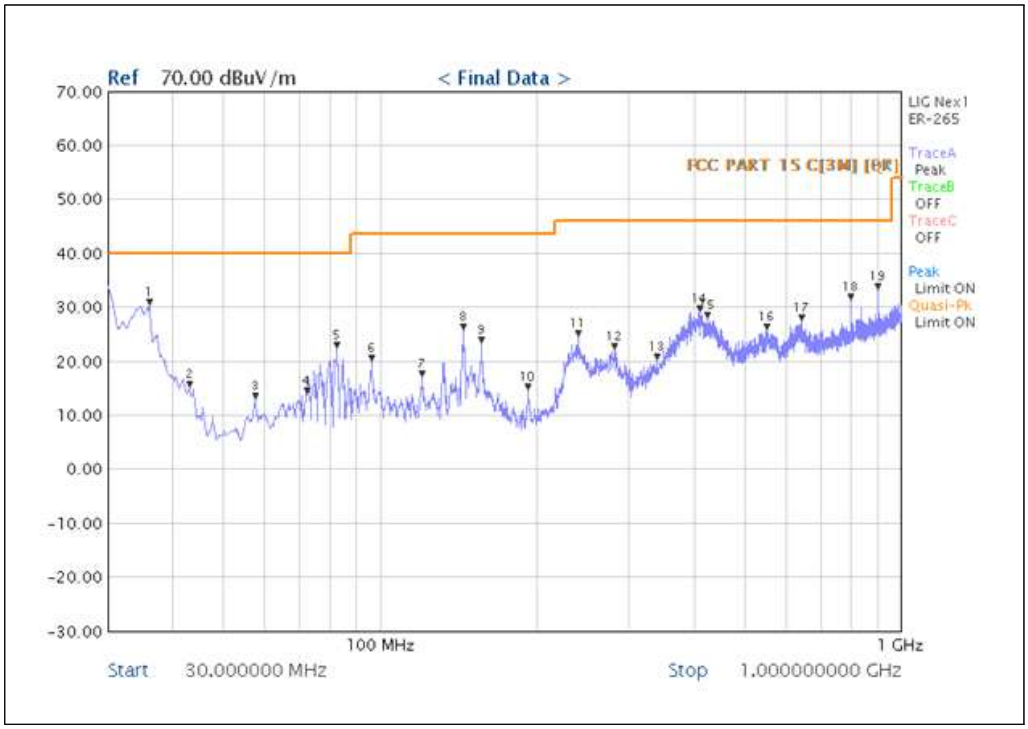
Vertical: Level (dBμV/m)



Frequency (MHz)	Detect Mode	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
143.98	Quasi-Peak	V	21.78	43.50	21.72
409.38	Quasi-Peak	V	28.75	46.00	17.25

* Remark:
1) The Emission Level values are included “Correction Factor”
2) Correction Factor = “Antenna Factor” + “Cable Loss” - “Amp. Gain”.

Horizontal: Level (dBμV/m)



Frequency (MHz)	Detect Mode	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
143.98	Quasi-Peak	H	19.72	43.50	23.78
409.71	Quasi-Peak	H	28.31	46.00	17.69

* Remark:
1) The Emission Level values are included “Correction Factor”
2) Correction Factor = “Antenna Factor” + “Cable Loss” - “Amp. Gain”.

c) Harminics & Spurious emissions for frequency range 1 GHz ~ 26.5 GHz.[Peak & Average Measurement]

Peak Measurement:

Frequency (MHz)	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2670.31	H	49.68	74.00	24.32
2673.43	V	49.83	74.00	24.17
5862.35	H	49.87	74.00	24.13
5913.47	V	50.12	74.00	23.88

Average Measurement:

Frequency (MHz)	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2690.17	H	42.81	54.00	11.19
2691.24	V	41.98	54.00	12.02
5789.46	V	41.67	54.00	12.33
5801.43	H	41.92	54.00	12.08

* Remark:
1) The Emission Level values are included “Correction Factor”
2) Correction Factor = “Antenna Factor” + “Cable Loss” - “Amp. Gain”
3) As shown in Section, for frequencies above 1 GHz. the above field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.
4) The test only perform the EUT in transmitting status since the test frequencies were over 1 GHz only required transmitting status.

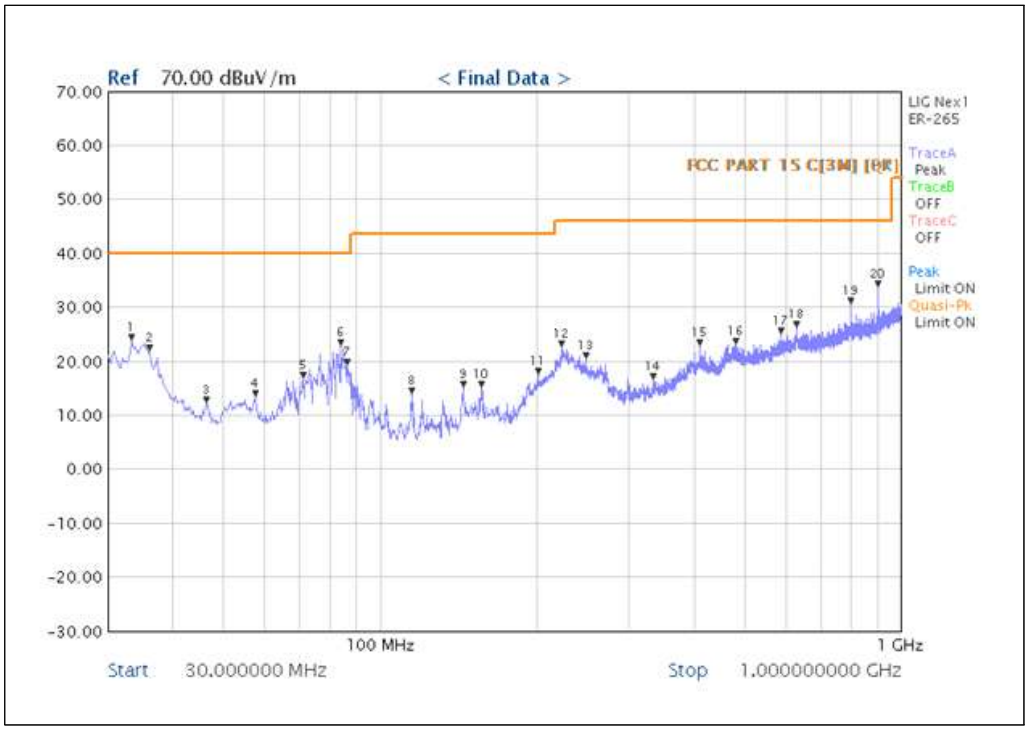
3) Test at high Channel (2 480 MHz) in transmitting status

a) Field Strength of unwanted emissions for frequency range 9 kHz ~ 30 MHz.
(Detect mode : Quasi-Peak)

The measurements with active loop antenna were greater than 20 dB below the limit, so the test data were not recorded in the test report.

b) Spurious emissions for frequency range 30 MHz ~ 1 GHz. (Detect mode : Quasi-Peak)

Vertical: Level (dBμV/m)

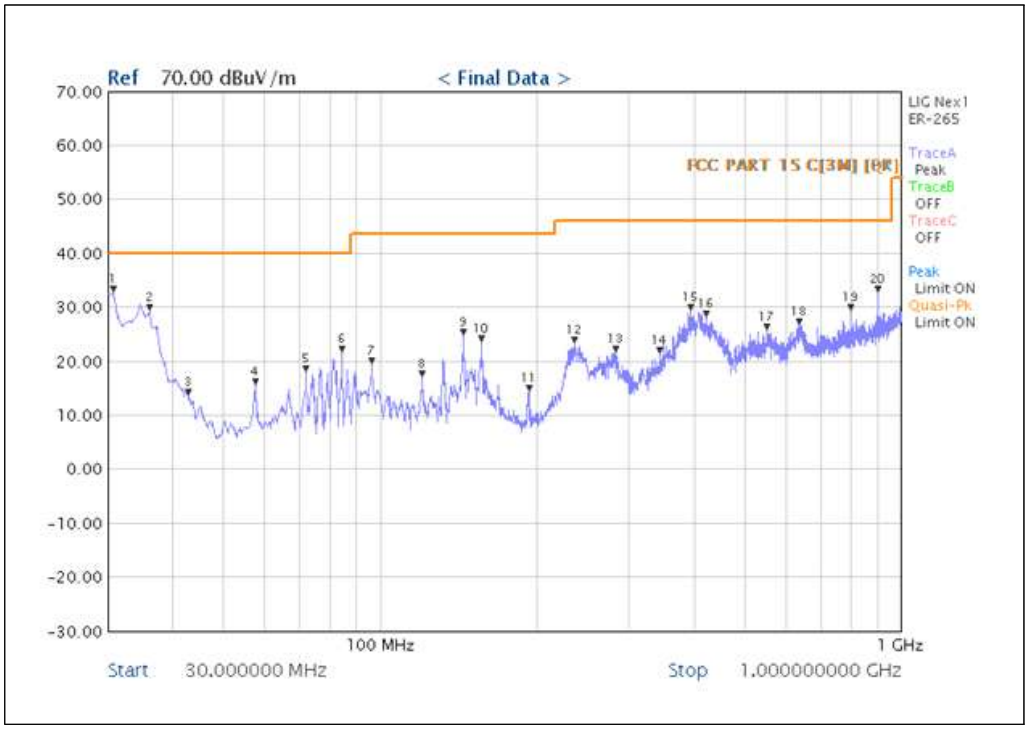


Quasi-peak measurement

Frequency (MHz)	Detect Mode	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
143.95	Quasi-Peak	V	24.54	43.50	18.96
409.45	Quasi-Peak	V	28.52	46.00	17.48

* Remark:
1) The Emission Level values are included “Correction Factor”
2) Correction Factor = “Antenna Factor” + “Cable Loss” - “Amp. Gain”.

Horizontal: Level (dBμV/m)



Quasi-peak measurement

Frequency (MHz)	Detect Mode	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
143.95	Quasi-Peak	H	17.63	43.50	25.87
409.56	Quasi-Peak	H	28.51	46.00	17.49

* Remark:
1) The Emission Level values are included “Correction Factor”
2) Correction Factor = “Antenna Factor” + “Cable Loss” - “Amp. Gain”.

c) Harmonics & Spurious emissions for frequency range 1 GHz ~ 26.5 GHz . [Peak & average measurement]

Peak Measurement:

Frequency (MHz)	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2680.84	H	48.79	74.00	25.21
2766.18	V	49.89	74.00	24.11
5782.34	V	48.27	74.00	25.73
5799.31	H	49.82	74.00	24.18

Average Measurement:

Frequency (MHz)	Polarization (V/H)	Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2683.47	H	41.69	54.00	12.31
2688.64	V	42.38	54.00	11.62
5762.15	H	42.03	54.00	11.97
5771.39	V	41.87	54.00	12.13

* Remark:
1) The Emission Level values are included “Correction Factor”
2) Correction Factor = “Antenna Factor” + “Cable Loss” - “Amp. Gain”
3) As shown in Section, for frequencies above 1 GHz. the above field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.
4) The test only perform the EUT in transmitting status since the test frequencies were over 1 GHz only required transmitting status.

4.8. Band Edges Compliance

4.8.1. Requirement

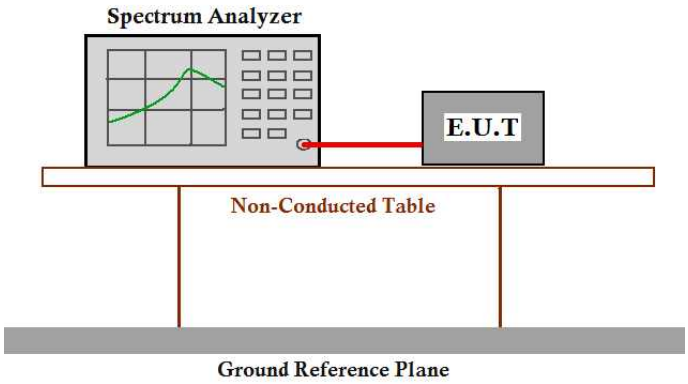
- FCC Part15 C section 15.247 (d) :

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

4.8.2. Test Method

KDB 558074 D01 v03r05 and ANSI C63.10

4.8.3. Test Configuration



4.8.4. Test Procedure

1)Remove the antenna from the EUT and then connect a low attenuation RF cable from the antenna port to the spectrum.

2) Set the spectrum analyzer:

a) Set start frequency to DTS channel edge frequency.

b) Set stop frequency so as to encompass the spectrum to be examined.

c) Set RBW = 100 kHz.

d) Set VBW ≥ 300 kHz.

e) Detector = peak.

f) Trace Mode = max hold.

g) Sweep = auto couple.

h) Allow the trace to stabilize (this may take some time, depending on the extent of the span).

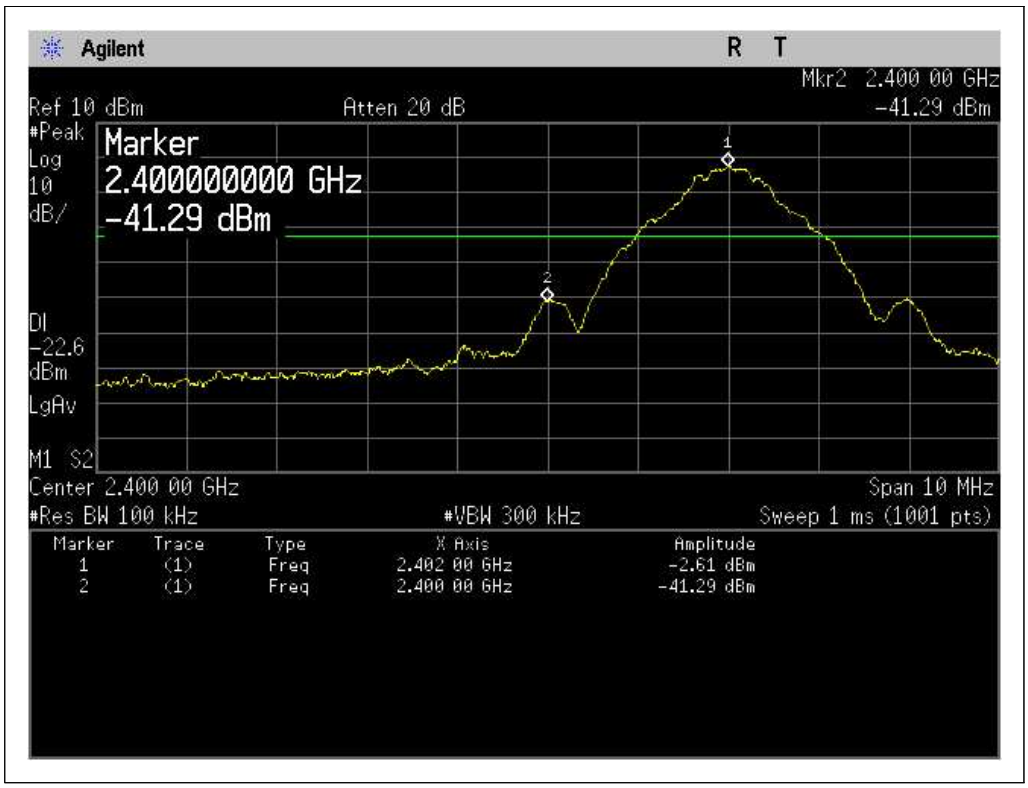
i) Use peak marker function to determine maximum amplitude of all unwanted emissions within any 100 kHz bandwidth.

4.8.5. Test result

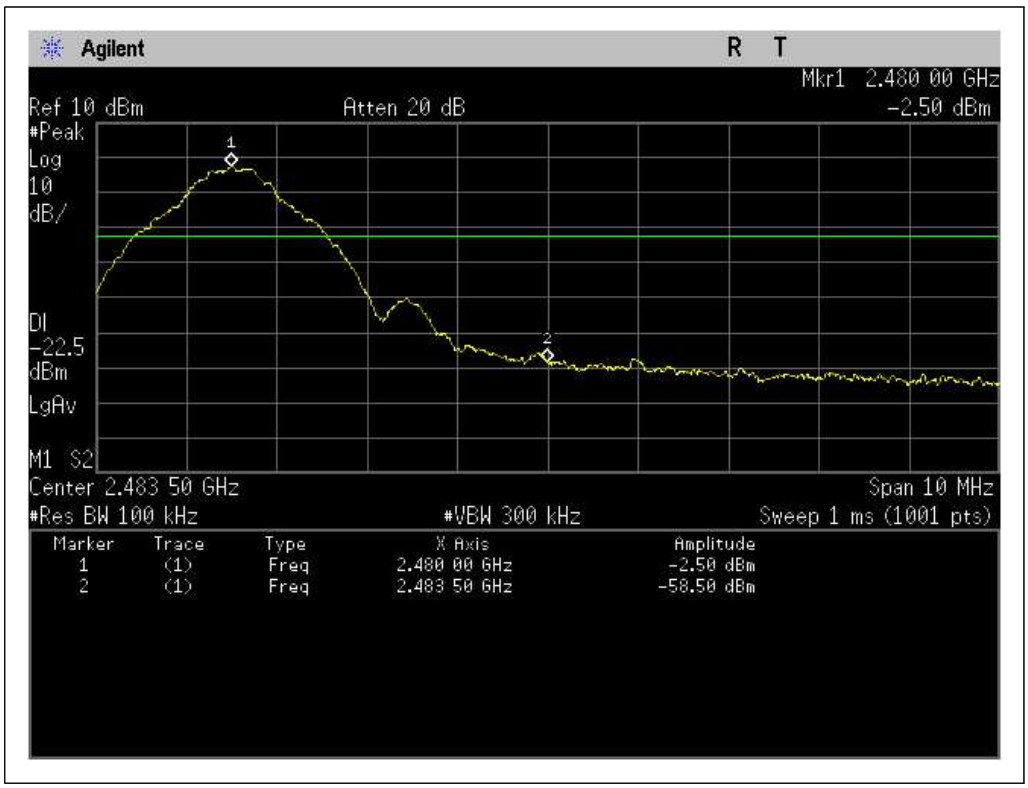
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum modulated EUT was operating, the radio frequency power that was produced by the EUT was at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on an RF conducted measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.The radio frequency power that was produced by the EUT was at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

Result plot as follows:

Low Channel(2 402 MHz):



High Channel(2 480 MHz):



4.9. AC Powerline Conducted Emission

4.9.1. Requirement

FCC Part 15 C section 15.207

4.9.2. Test Method

ANSI C63.4

1) Frequency Range

150 kHz to 30 MHz

2) Detector

Peak for pre-scan (9 kHz Resolution Bandwidth)

3) Test Limit

Limits for conducted disturbance at the mains ports of class B

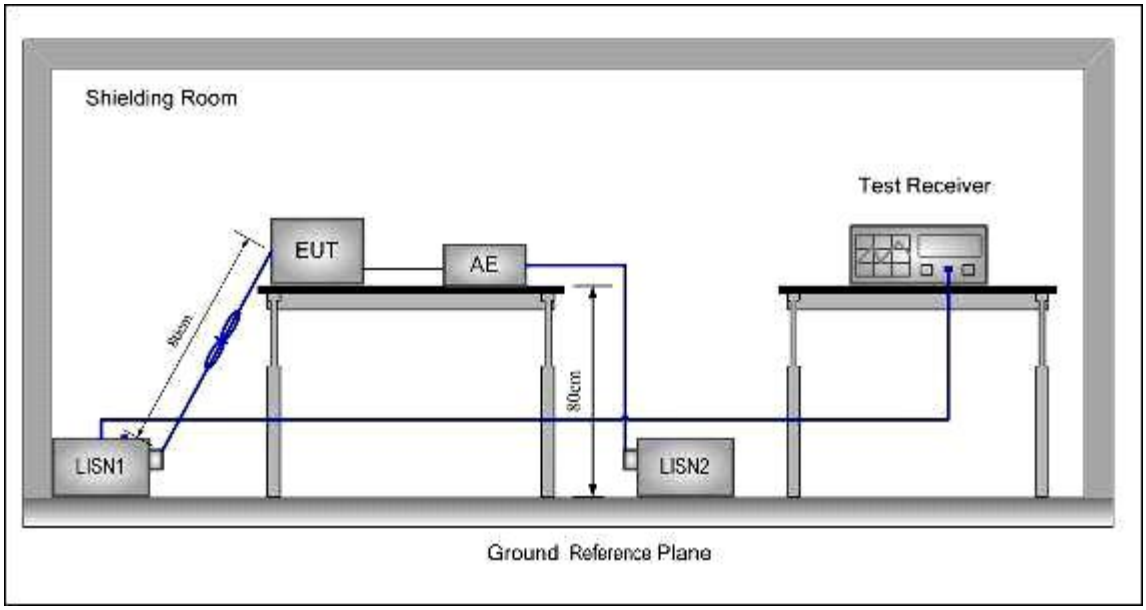
Frequency Range (MHz)	Class B Limit dB(μV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50
NOTE 1 The limit decreases linearly with the logarithm of the frequency in the range 0,15 MHz to 0,50 MHz.		

4) EUT Operation

The test mode was normal operating mode. For intentional radiators, the measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage.

Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture).

4.9.3. Test Configuration



4.9.4. Test procedure

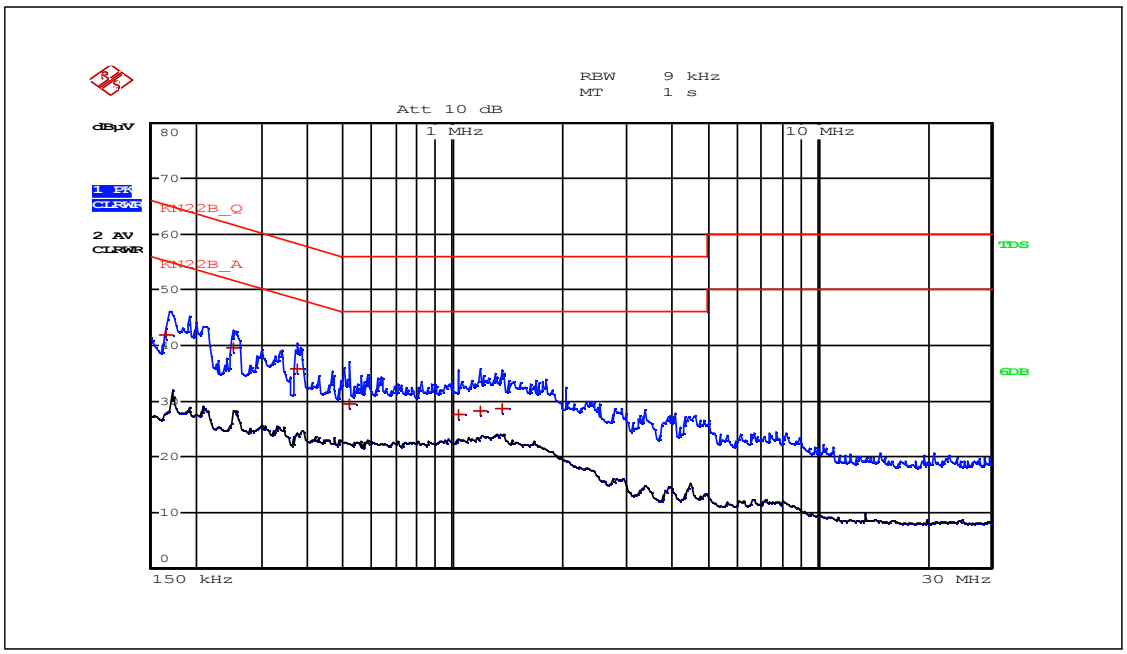
1) The mains terminal disturbance voltage test was conducted in a shielded room.
2) The EUT was connected to AC power source through a LISN 1 (Line Impedance Stabilization Network) which provides a 50/50µH + 5linear impedance. The power cables of all other units of the EUT were connected to a second LISN 2, which was bonded to the ground reference plane in the same way as the LISN 1 for the unit being measured. A multiple socket outlet strip was used to connect multiple power cables to a single LISN provided the rating of the LISN was not exceeded.
3) The tabletop EUT was placed upon a non-metallic table 0.8m above the ground reference plane. And for floor-standing arrangement, the EUT was placed on the horizontal ground reference plane, but separated from metallic contact with the ground reference plane by 0.1m of insulation.
4) The test was performed with a vertical ground reference plane. The rear of the EUT shall be 0,4 m from the vertical ground reference plane. The vertical ground reference plane was bonded to the horizontal ground reference plane. The LISN 1 was placed 0,8 m from the boundary of the unit under test and bonded to a ground reference plane for LISNs mounted on top of the ground reference plane.
This distance was between the closest points of the LISN 1 and the EUT. All other units of the EUT and associated equipment was at least 0,8 m from the LISN 2.

4.9.5. Test result

Pre-scan was performed with peak detected on all ports, Quasi-peak & average measurements were performed at the frequencies at which maximum peak emission level were detected.

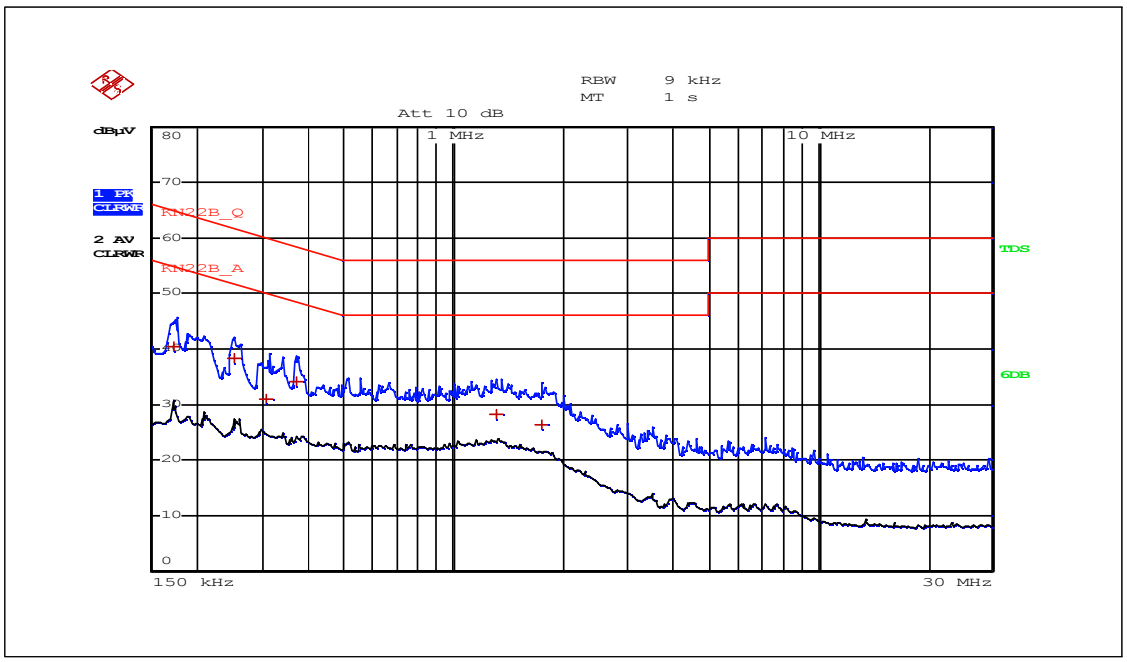
Please see the attached Quasi-peak and Average test results.

Hot Line – PE(Peak and Average detector used)



Date: 11.OCT.2016 09:17:13

Neutral Line – PE(Peak and Average detector used)



Date: 11.OCT.2016 09:21:33

Frequency (MHz)	Line (H/N)	Quasi-Peak			Average		
		Emission Level (dBμV)	Limit (dBμV)	Margin (dB)	Emission Level (dBμV)	Limit (dBμV)	Margin (dB)
0.166	H	41.91	65.16	23.25	-	-	-
0.174	N	40.46	64.77	24.31	-	-	-
0.250	H	39.53	61.76	22.23	-	-	-
0.250	N	38.35	61.76	23.41	-	-	-
0.310	N	30.92	59.97	29.05	-	-	-
0.370	N	34.20	58.50	24.30	-	-	-
0.374	H	35.81	58.41	22.60	-	-	-
0.518	H	29.41	56.00	26.59	-	-	-
1.034	H	27.57	56.00	28.43	-	-	-
1.190	H	28.15	56.00	27.85	-	-	-
1.306	N	28.19	56.00	27.81	-	-	-
1.374	H	28.61	56.00	27.39	-	-	-
1.758	N	26.25	56.00	29.75	-	-	-

* Remark:
1) Margin (dB) = Limit − Emission Level
2) Emission Level = Measured Value + LISN Factor + Cable Loss
3) “H”: Hot Line, “N”: Neutral Line
4) Peak and quasi-peak values is omitted because it is the average measurement result is below the average reference value.

4.10. Radio Frequency Exposure Procedures

4.10.1. Requirement

According to §15.247(i) and § 1.1310, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

Limit of Maximum Permissible Exposure:

Limits for Occupational / Controlled Exposure				
Frequency Range (MHz)	**Electric Field Strength (E) (V/m)**	**Magnetic Field Strength (H) (A/m)**	**Power Density (S) (mW/ cm²)**	**Averaging Time |E|², |H|² or S (minutes)**
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842 / f	4.89 / f	(900 / f^2)*	6
30-300	61.4	0.163	1.0	6
300-1500	-	-	F/300	6
1500-100,000	-	-	5	6
Limits for General Population / Uncontrolled Exposure				
Frequency Range (MHz)	**Electric Field Strength (E) (V/m)**	**Magnetic Field Strength (H) (A/m)**	**Power Density (S) (mW/ cm²)**	**Averaging Time |E|², |H|² or S (minutes)**
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f^2)*	30
30-300	27.5	0.073	0.2	30
300-1500	-	-	F/1500	30
1500-100,000	-	-	1.0	30
Note 1: f = frequency in MHz ; *Plane-wave equivalent power density Note 2: For the applicable limit, see FCC 1.1310				

4.10.2. Conclusion

1) Maximum Measured Transmitter Power:

Channel Frequency (MHz)	Maximum Peak Conducted Output Power		Max Antenna Gain (dBi)	Numeric antenna gain (mW)
	(dBm)	(mW)		
2 440	-2.26	0.59	0.5	1.12

For Mobile RF Exposure Evaluation: The power density (S) should be **< 1.0 mW/cm²** to meet the exemption**.**
Combine two equations for Field Strength and Power density, you can come up to this formula:
$S = (30*P*G)/(377d^2) = (30*0.59*1.12)/377*(20)^2 = 1.315$ mW/cm²
With: S: Power Density (mW/cm²).
P: Transmitter power (mW); G: Max Ant Gain (dBi); d: Distance (cm).